From: Rachel Pernic Waldron [rpernicwaldron@kirkland.com]
Sent: Thursday, January 18, 2007 4:31 PM
To: Goettle, Daniel J. (Woodcock Washburn)
Cc: Michael Parks; Shira Kapplin
Subject: RE: TruePosition v. Andrew: Draft Joint Claim Construction Statement

Dan --

Attached are amended claim constructions. Please let us know if TruePosition would like to discuss.

We assume that TruePosition, as plaintiff, will create the master document for the Court, and will send it to us for approval before filing -- please let us know if this is incorrect.

Thank you,
Rachel

Rachel Pernic Waldron
KIRKLAND & ELLIS LLP
200 E. Randolph Drive
Chicago, IL 60601
Phone: 312.861.3371
Fax: 312.861.2200

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Claim Term	Andrew's Proposed Construction	TruePosition's Proposed Construction
Reverse control channels	A channel that carries only signaling information from a mobile terminal to a base station in the format specified in ANSI 553	
Database means for [1] storing location data identifying the cellular telephones and their respective locations, and [2] for providing access to said database to subscribers at remote locations	• Function: storing location data identifying the cellular telephones and their respective locations, and for providing access to the database to subscribers at remote locations • Structure: a database or local disk storage device containing the unique code corresponding to each cellular telephone and a terminal coupled to the database via (1) modem and telephone line, or (2) radio communication providing access to the database to the subscribers	
Means for determining, on the basis of said times of arrival differences, the locations of the cellular telephones responsible for said cellular telephone signals Determining	• Function: to determine on the basis of time of arrival differences, the locations of the mobile cellular telephones whose signals are received • Structure: algorithms disclosed in '144 Pat. Col.16, line 5 - Col. 19, line 2, and Figures cited therein	
Time stamp bits representing the time at which said cellular telephone signals were received	Binary digits representing the calendar date and clock time at which signals were received at the cell site	

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Claim Term	Andrew's Proposed Construction	TruePosition's Proposed Construction
Time stamp bits representing the time at which said frames were produced at each cell site	Binary digits representing the calendar date and clock time at which said frames were produced at each cell site	
Claim 1: table identifying individual cellular telephone signals	Table containing a code uniquely associated with the cellular telephone that transmitted the signals	
Claim 22 and Claim 32: data identifying the cellular telephones	The code uniquely associated with the cellular telephone	
Claim 31: processing said frames of data to identify individual cellular telephone signals	Extracting from the data frames a code uniquely associated with the cellular telephone that transmitted the signals	
Initiating	No explicit construction required	
Locating means for automatically determining the locations of said cellular telephones by receiving and processing signals emitted during said periodic reverse control channel transmissions	• Function: automatically determine the location of cellular telephones by monitoring every periodic reverse control channel transmission emitted from every mobile cellular telephone in the network to determine the location of all such mobile cellular telephones without a specific request to locate them, and processing the signals emitted during the phones' reverse control channel transmissions • Structure: algorithms disclosed in '144 Pat. Col.16, line 5 - Col. 19, line 2, and Figures cited therein	

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Periodic	Occurring at regular intervals	
Periodically		
Prescribed set	The set of frequency bands that are assigned to convey information in the format specified in ANSI 553	
Means for processing said frames of data from said cell site systems to generate a table	• Function: to generate a table • Structure: The elements recited in figures 6 and 6A, the operations reflected in Figure 7, including algorithms disclosed in the patent	
Processing		
Reverse	Should not be construed separately from the unitary phrase "reverse control channel"	
Subscribers	Users of the mobile cellular telephones who receive and pay for cellular telephone service	
Timing signal	Signal that is provided to all cell sites to generate a time stamp for each frame of data	

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A239

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

TruePosition, Inc.,	)	
	)	
Plaintiff/	)	
Counterclaim-Defendant,	)	
	)	Civil Action No. 05-747-SLR
v.	)	
	)	
Andrew Corporation,	)	
	)	
Defendant/	)	
Counterclaim-Plaintiff.	)	
	)	

JOINT CLAIM CONSTRUCTION STATEMENT

Pursuant to paragraph 7 of the Scheduling Order entered on March 10, 2006, plaintiff and

counterclaim defendant TruePosition, Inc. ("TruePosition") and defendant and counterclaim plaintiff

Andrew Corporation ("Andrew") jointly submit this Joint Claim Construction Statement identifying

for the Court the disputed claim terms in U.S. Patent No. 5,327,144. Andrew contends that: the

parties are requesting the Court to construe only a subset of the limitations required by the asserted

claims; and excluding a claim limitation from this Joint Claim Construction Statement is not a

concession by Andrew that the limitation is present in the accused products.

144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
Initiating (Claims 1, 22)	No explicit construction is required. To the extent the Court decides otherwise, the term means: Causing or facilitating the beginning of	Causing or bringing about
Periodic (Claims 1, 22)	No explicit construction is required. To the extent the Court decides otherwise, the term means: Discontinuous(ly)	Occurring at regular intervals
Periodically (Claim 31)		

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
Prescribed set (Claims 1, 22, 31)	Andrew has taken this phrase out of context. To the extent the Court chooses to construe this phrase out of context, the phrase means: Set described by a cellular telephone system protocol	The set of frequency bands that are assigned to convey information in the format specified in ANSI 553
Reverse control channel(s) (Claims 1, 22, 31)	A **control channel(s)** from a cellular telephone(s) to a cell site(s)	A channel that carries only signaling information from a mobile terminal to a base station in the format specified in ANSI 553
Reverse (Claims 1, 22, 31)	From a cellular telephone(s) to a cell site(s)	Should not be construed separately from the unitary phrase "reverse control channel" To the extent the Court chooses to construe "reverse" out of context, it means: From a mobile terminal to a base station, in the format specified by ANSI 553
Control Channel(s) (Claims 1, 22, 31)	Channel(s) used to transmit control information to and from a cellular telephone(s); not voice channel(s)	Should not be construed separately from the unitary phrase "reverse control channel" To the extent the Court chooses to construe "control channel" out of context, it means: A channel that carries only signaling information in the format specified by ANSI 553
Timing Signal (Claims 1, 2)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: Signal that conveys timing information	Signal that is provided to all cell sites to generate a time stamp for each frame of data

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
Time stamp bits representing the time at which said cellular telephone signals were received (Claim 1)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: Binary units of computer information that indicate a time and that symbolize, typify or describe when said cellular telephone signals were received.	Binary digits representing the calendar date and clock time at which signals were received at the cell site
"means for processing said frames of data from said cell site systems to generate a table identifying individual cellular telephone signals and the differences in times of arrival of said cellular telephone signals among said cell site systems" (Claim 1)	• Function: processing said frames of data from said cell site systems to generate a table identifying individual cellular telephone signals and the differences in times of arrival of said cellular telephone signals among said cell site systems • Structure: A computer processor programmed to perform the algorithm disclosed at Col. 13, ll. 33-56 (ending with the acronym "TDOA"), Fig. 7 at the First Four Blocks and Table, Co. 17, ll. 26-68 (minus any reference to "frequency difference data" or "frequency difference results") and Figs. 8a-8b (minus any reference to "frequency differences"), or equivalents of such a computer processor.	• Function: to generate a table • Structure: The elements recited in figures 6 and 6A, the operations reflected in Figure 7, including algorithms disclosed in the patent
Processing (Claims 1, 22, 31)	No explicit construction is required. To the extent the Court decides otherwise, the term means: Analyzing with a computer(s).	• Function: to generate a table • Structure: The elements recited in figures 6 and 6A, the operations reflected in Figure 7, including algorithms disclosed in the patent
Table identifying individual cellular telephone signals (Claim 1)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: Table identifying particular cellular telephone signals.	Table containing a code uniquely associated with the cellular telephone that transmitted the signals

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
"means for determining, on the basis of said times of arrival differences, the locations of the cellular telephones responsible for said cellular telephone signals" (Claim 1)	• Function: determining, on the basis of said times of arrival differences, the locations of the cellular telephones responsible for said cellular telephone signals • Structure: A computer processor programmed to perform the algorithm disclosed at Col. 13, l. 58 (beginning with the word "This") through Col. 13, l. 62 (ending with the letter "C"), Fig. 7, at the Fifth and Sixth Blocks, Col. 18, ll. 1-34 (ending with "0.0001," but minus any reference to "frequencies") and Fig. 8c through Top Four Elements of Fig. 8d (minus any reference to "frequencies"), or equivalents of such a computer processor.	• Function: to determine on the basis of time of arrival differences, the locations of the mobile cellular telephones whose signals are received • Structure: algorithms disclosed in '144 Pat. Col.16, line 5 - Col. 19, line 2, and Figures cited therein
Determining (Claims 1, 22, 31)	No explicit construction is required. To the extent that the Court decides otherwise, the term means: Arriving at a decision about.	• Function: to determine on the basis of time of arrival differences, the locations of the mobile cellular telephones whose signals are received • Structure: algorithms disclosed in '144 Pat. Col.16, line 5 - Col. 19, line 2, and Figures cited therein
Subscribers (Claims 22, 32)	No explicit construction is required. To the extent the Court decides otherwise, the term means: Individuals who agree to receive and pay for a service.	Users of the mobile cellular telephones who receive and pay for cellular telephone service

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
"locating means for automatically determining the locations of said cellular telephones by receiving and processing signals emitted during said periodic reverse control channel transmissions" (Claim 22)	• Function: automatically determining the locations of said cellular telephones by receiving and processing signals emitted during said periodic reverse control channel transmissions. • Structure: A computer processor programmed to perform the algorithm disclosed at Col. 13, ll. 33-62 (ending with the letter "C"), Figure 7 at the First Six Blocks and Table, Col. 17, l. 26 – Col. 18, l. 34 (ending with "0.00001," but minus any reference to "frequency difference data," "frequency difference results" or "frequencies") and Figs. 8a through the Top Four Elements of Fig. 8d (minus any reference to "frequency differences" or "frequencies"), or equivalents of such a computer processor.	• Function: automatically determine the location of cellular telephones by monitoring every periodic reverse control channel transmission emitted from every mobile cellular telephone in the network to determine the location of all such mobile cellular telephones without a specific request to locate them, and processing the signals emitted during the phones' reverse control channel transmissions • Structure: algorithms disclosed in '144 Pat. Col.16, line 5 - Col. 19, line 2, and Figures cited therein

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
"database means for storing location data identifying the cellular telephones and their respective locations, and for providing access to said database to subscribers at remote locations " (Claim 22)	• Function: storing location data identifying the cellular telephones and their respective locations, and for providing access to said database to subscribers at remote locations. • Structure: The combination of the "database 20" and the "first terminal 22 coupled via a modem . . . and telephone line to the database 20" disclosed in Col. 9, ll. 25-27, Fig. 2 Blocks 20, 22, or equivalents of such a combination; Or • Structure: The combination of the "database 20" and the "second terminal 24 in radio communication with the database 20" disclosed in Col. 9, ll. 27-29, Fig. 2, Blocks 20, 24, or equivalents of such a combination; Or • Structure: The combination of the "database 20" and the "third, handheld terminal 26, which is carried by a user who also has a cellular telephone 10b, in radio communication with the database" disclosed in Column 9, ll. 29-31, Fig. 2, Blocks 20, 26, or equivalents of such a combination.	• Function: storing location data identifying the cellular telephones and their respective locations, and for providing access to the database to subscribers at remote locations • Structure: a database or local disk storage device containing the unique code corresponding to each cellular telephone and a terminal coupled to the database via (1) modem and telephone line, or (2) radio communication providing access to the database to the subscribers

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144 Patent Claim Term or Phrase	TruePosition's Proposed Construction	Andrew's Proposed Construction
data identifying the cellular telephones (Claims 22, 32)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: In Claim 22, Data identifying the "multiple mobile cellular telephones each initiating periodic signal transmissions over one of a prescribed set of reverse control channels" recited in claim 22 In Claim 32, Data identifying the "cellular telephones responsible for said cellular telephone signals" recited in claim 31	The code uniquely associated with the cellular telephone
Processing said frames of data to identify individual cellular telephone signals (Claim 31)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: Processing said frames of data to identify particular cellular telephone signals.	Extracting from the data frames a code uniquely associated with the cellular telephone that transmitted the signals
Time stamp bits representing the time at which said frames were produced at each cell site (Claim 31)	No explicit construction is required. To the extent the Court decides otherwise, the phrase means: Binary units of computer information that indicate a time and that symbolize, typify or describe when said frames were produced at each cell site.	Binary digits representing the calendar date and clock time at which said frames were produced at each cell site

Dated: January 19, 2006

By:

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/s/ Francis DiGiovanni (No. 3189) for   .
CONNOLLY BOVE LODGE & HUTZ LLP
Rudolf E. Hutz, Esq. (No. 484)
James D. Heisman, Esq. (No. 2746)
The Nemours Building
1007 North Orange St.
PO Box 2207
Wilmington, Delaware 19899
(302) 658-9141

WOODCOCK WASHBURN LLP
Dale M. Heist (pro hac vice)
Paul B. Milcetic (pro hac vice)
David L. Marcus (pro hac vice)
Kathleen A. Milsark (pro hac vice)
Daniel J. Goettle (pro hac vice)
Cira Center, 12th Floor
2929 Arch Street
Philadelphia, PA 19104-2891
(215) 568-3100

Attorneys for TruePosition

/s/ Andrew A. Lundgren   .
YOUNG CONAWAY STARGATT &
  TAYLOR, LLP
Josy W. Ingersoll (No. 1088)
Karen L. Pascale (No. 2903)
Andrew A. Lundgren (No. 4429)
100 West Street, 17th Floor
Wilmington, Delaware 19801
(302) 571-6600

KIRKLAND & ELLIS, LLP
John D. Desmarais
Citigroup Center
153 East 53rd Street
New York, New York 10022
(212) 446-4800

KIRKLAND & ELLIS, LLP
Michael A. Parks
Rachel P. Waldron
Shira J. Kapplin
200 East Randolph Drive
Chicago, IL 60601
(312) 861-2000

DUANE MORRIS LLP
Patrick D. McPherson
1667 K Street, N.W., Suite 700
Washington, DC 20006
(202) 776-7800

Attorneys for Andrew

YOUNG CONAWAY STARGATT & TAYLOR, LLP

JOSY W. INGERSOLL (NO. 1088)
DIRECT DIAL: 302-571-6672
DIRECT FAX: 302-576-3301
jingersoll@ycst.com

THE BRANDYWINE BUILDING
1000 WEST STREET, 17TH FLOOR
WILMINGTON, DELAWARE 19801

P.O. BOX 391
WILMINGTON, DELAWARE 19899-0391

(302) 571-6600
(302) 571-1253 FAX
(800) 253-2234 (DE ONLY)
www.youngconaway.com

January 30, 2007

BY E-FILE

The Honorable Sue L. Robinson
United States District Court
844 King Street
Wilmington, Delaware 19801

      Re: *TruePosition Inc. v. Andrew Corp.*, C.A. No. 05-747-SLR

Dear Chief Judge Robinson:

      I write on behalf of Andrew Corporation regarding the claim construction in the above matter.

      Andrew wishes to inform the Court that it agrees with TruePosition that the following claim terms listed in the January 19, 2007 Joint Claim Construction Statement (D.I. 130) do not require construction by the Court:

> Initiating
> Periodic
> Periodically
> Timing Signal
> Determining
> Processing
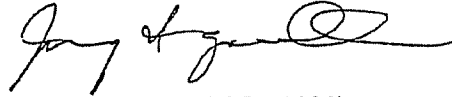
      In addition, for clarification, Andrew agrees with TruePosition on the function (but not the structure) for the "means for processing said frames of data from said cell site systems to generate a table identifying individual cellular telephone signals and the differences in times of arrival of said cellular telephone signals among said cell site systems" limitation in claim 1 is:

> "processing said frames of data from said cell site systems to generate a table identifying individual cellular telephone signals and the differences in times of arrival of said cellular telephone signals among said cell site systems."

DB02:5757623.1

065217.1001

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YOUNG CONAWAY STARGATT & TAYLOR, LLP
The Honorable Sue L. Robinson
January 30, 2007
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Andrew therefore will not address the above issues in its opening Markman brief.

Respectfully submitted,

Josy W. Ingersoll (No. 1088)

JWI:cg
cc: Clerk of the Court (by CM/ECF and hand delivery)
       James D. Heisman, Esquire (by CM/ECF and e-mail)
       Paul B. Milcetic, Esquire (by e-mail)
       Michael Parks, Esquire (by e-mail)
       Rachel Pernic Waldron, Esquire (by e-mail)

GSM and PCNs

Overview Of The GSM System and Protocol Architecture

We can use GSM as a basic framework to define and develop the standards for handling the mobility-specific functions of next-generation PCNs.

Moe Rahnema

Global system for mobile telecommunication (GSM) comprises the CEPT-defined standardization of the services, functional/subsystem interfaces, and protocol architecture, based on the use of worldwide standards produced by CCITT and CCIR, for a pan-European digital land mobile system primarily intended to serve users in motor vehicles. The digital mobile radio networks, for which GSM represents the European standards, provide powerful message signaling capabilities that facilitate and enhance roaming, compared to the first generation analogue systems, through automatic network location detection and registration.

GSM provides terminal mobility, with personal mobility provided through the insertion of a subscriber identity module (SIM) into the GSM network (mobile station). The SIM carries the personal number assigned to the mobile user. The GSM-based cellular mobile networks are currently in widespread use in Europe. At the present time, the next generation of personal communication services (PCS) beyond GSM is also being considered. These third generation systems, known as universal personal communication networks (PCN) will be using lower power handsets to provide personal mobility to pedestrians, as well. The PCS low-power handsets are expected to eliminate the need to have different handsets for wide-area (cellular) and local (cordless) applications. The universal PCS will also provide a higher quality of personal-service mobility across the boundaries of many different networks (mobile and fixed, wide- and local-area).

Many network capabilities, however, such as mobility management, user security protection, and resource allocation, addressed in GSM, are also some of the critical requirements and issues in UPC networks of the future. GSM is expected to play a major role in the specification of the standards for UPC. In the United Kingdom, PCN is already being designed and deployed with close adherence to the GSM standards other than the different operating frequencies (GSM operates at 900 MHz and the United Kingdom PCN operates at 1800 MHz). Generally, GSM may be viewed as a framework for studying the functions and issues that

are specific to cellular type personal communication networks, whatever the means of implementation might be.

In applying and extending GSM to the next generation personal communication networks, however, one should be careful in differentiating some of the implementation specifics unique to the GSM network architecture and application from the functions and issues that would be more or less generally applicable and relevant to cellular networking. It is with this point in mind that the reader should view GSM as a framework or platform on which to build his or her vision of how GSM may be used as a guide to design and build the next generation networks. In that regard, a good understanding of the GSM standards and network functions is essential for the professional working on the next generation personal communication networks. This article is intended to assist with this objective.

The Cellular Concept

Cellular mobile communication is based on the concept of frequency reuse. That is, the limited spectrum allocated to the service is partitioned into, for example, N non-overlapping channel sets, which are then assigned in a regular repeated pattern to a hexagonal cell grid. The hexagon is just a convenient idealization that approximates the shape of a circle (the constant signal level contour from an omnidirectional antenna placed at the center) but forms a grid with no gaps or overlaps. The choice of N is dependent on many trade-offs involving the local propagation environment, traffic distribution, and costs. The propagation environment determines the interference received from neighboring co-channel cells which in turn governs the reuse distance, that is, the distance allowed between co-channel cells (cells using the same set of frequency channels).

The cell size determination is usually based on the local traffic distribution and demand. The more the concentration of traffic demand in the area, the smaller the cell has to be sized in order to avail the frequency set to a smaller number of roaming

MOE RAHNEMA is a principal communication engineer at Motorola Satellite Communications.

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subscribers and thus limit the call blocking probability within the cell. On the other hand, the smaller the cell is sized, the more equipment will be needed in the system as each cell requires the necessary transceiver and switching equipment, known as the base station subsystem (BSS), through which the mobile users access the network over radio links. The degree to which the allocated frequency spectrum is reused over the cellular service area, however, determines the spectrum efficiency in cellular systems. That means the smaller the cell size, and the smaller the number of cells in the reuse geometry, the higher will be the spectrum usage efficiency. Since digital modulation systems can operate with a smaller signal to noise (i.e., signal to interference) ratio for the same service quality, they, in one respect, would allow smaller reuse distance and thus provide higher spectrum efficiency. This is one advantage the digital cellular provides over the older analogue cellular radio communication systems. The interested reader may refer to [1,2] for the details on spectrum efficiency analysis in cellular network.

It is worth mentioning that the digital systems have commonly used sectored cells with 120-degree or smaller directional antennas to further lower the effective reuse distance. This allows a smaller number of cells in the reuse pattern and makes a larger fraction of the total frequency spectrum available within each cell. Currently, research is being done on implementing other enhancements such as the use of dynamic channel assignment strategies for raising the spectrum efficiency in certain cases, such as high uneven traffic distribution over cells.

The Network Infrastructure

The cellular concept of networking is based on the superposition of a distributed star type network architecture on the existing fixed landline telephony communication infrastructure. The basic network architecture is illustrated in Fig. 1. The telephony network is used to provide not only the communication links between a mobile user and a fixed landline user, but also to provide the connectivity between the mobile users roaming in remotely located cells or in the domain of mobile networks operated by different service providers. The BSSs, provide management of the radio resources, and the switching between the radio channels and the TDM slots on their connections with the mobile switching center (MSC). MSCs link groups of neighboring BSSs through point-to-point landline or microwave-based E1 trunks. The MSC acts as the nerve center of the system. It controls call signaling and processing, and coordinates the handover of the mobile connection from one base station to another as the mobile roams around. Each MSC is in turn connected to the local public switched telephony network (PSTN, or ISDN) to provide the connectivity between the mobile and the fixed telephony users, as well as the necessary global connectivity among the MSCs of the cellular mobile network. This is intended to make it possible for any mobile user to communicate with any other mobile or fixed telephony user in the world. Thus, the global connectivity provided by the existing landline telephony infrastructure is used to link up the cellular mobile subscribers
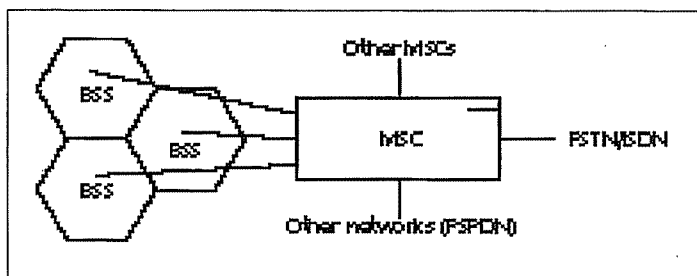
Cellular network infrastructure.

throughout the world.

Direct links between certain "local" MSCs may also be provided to allow the communication between two mobile users to bypass the telephony network when there is considerable traffic flow between the mobile users roaming in the areas under the coverage of those MSCs. Thus, the communication path between any two mobile users roaming under the coverage of two "local" MSCs may or may not switch through the public telephony network. It depends on the connectivity provided between the two MSCs. The MSC may also connect to public data networks (PDN), such as the packet-switched networks, to provide the mobiles with access to data services.

Network Databases and Standardization

GSM defines a number of network databases that are used in performing the functions of mobility management and call control in a public land mobile network (PLMN). These elements include the location registers consisting of the home location register (HLR), and the visiting location register (VLR), the equipment identity register (EIR), and the authentication center (AC). The HLR maintains and updates the mobile subscriber's location and his or her service profile information. The VLR maintains the same information locally, where the subscriber is roaming. The VLR is defined as a stand-alone function (see following paragraph), but is usually viewed by vendors as part of the MSC. These registers are called service control points (SCP) in the terminology used in intelligent networking (IN). The EIR is used to list the subscribers' equipment identities, which are used for identification of unauthorized subscriber equipment, and hence denial of service by the network. The AC provides the keys and algorithm for maintaining the security of subscriber identities, and for encrypting information passed over the air interface. The MSC is equipped with a service switching point (SSP) module which is used to query the databases such as a location register to identify where a mobile subscriber is located and what his or her service profile is, for the routing, and processing of calls to (or by) the subscriber.

The GSM specifications have defined logically separate functions and standard interfaces for each of the databases, to allow each function to be implemented on a physically separate network component. The interfaces are specified via the mobile application part (MAP) that uses the transaction capability applications part (TCAP) of (SS7). These are all elements of an IN. GSM is considered an

In GSM, the radio channels are based on a TDMA structure that is implemented on multiple frequency subbands (TDMA/ FDMA).

IN application and GSM providers are considering the GSM implementation as experience in intelligent networking.

Numbering Plan

The numbering consists of at least one international ISDN number allocated to either the mobile subscriber, if the mobile is card operated, or to the mobile station, otherwise. The mobile station ISDN (MSISDN) conforms to the CCITT E.164 recommendation, and should, in each country, comply to that country's ISDN numbering plan. The MSISDN number basically consists of a country code (CC), a "national destination code (NDC), which specifies a PLMN within that country, and a subscriber number (SN). This structure is shown in Fig. 2.

The MSISDN number is used for dialing by a calling subscriber from the PSTN/ISDN, and is used to route the call to the gateway MSC of the GSM network. The GSM MSC then uses the MSISDN to interrogate the appropriate HLR for the re-routing information required to extend the call to the mobile's visiting MSC.

The rerouting information is specified by the mobile station roaming number (MSRN) which is obtained from the HLR and is used to progress the call to the called mobile. The MSRN is a temporary number, allocated by the VLR (associated with the mobile's visiting MSC) and sent to the mobile's HLR either on location update (discussed in a later section) or on a per call basis. The MSRN has the same structure as the MSISDN numbers in the visiting location area where it is allocated.

For provision of mobile packet data services, a mobile international data number conforming to CCITT recommendation X.121 may be specified. GSM recommendation 03.70 discusses the requirements for the numbering interworking functions required in this case.

Addressing and Call Routing

The MSISDN number is used for the routing of calls within the PSTN/ISDN networks. The details of call routing requirements are discussed in GSM recommendation 03.04. The following paragraphs provide a summary discussion of possible scenarios involved in call routing.

National Calls from the Fixed Network

A local or transit exchange, when receiving a call destined for a mobile, recognizes the NDC, and routes the call to a gateway MSC. The gateway MSC performs the HLR query for the MSRN, which it then uses to reroute the call.

International Calls from the Fixed Network

When a local or transit exchange receives an international call and recognizes the international prefix, it routes the call to the nearest ISC. The ISC recognizes that the NDC indicates a PLMN. If it can support HLR query (i.e., if it has TCAP signaling connectivity to the HLR) it queries the HLR and receives the called subscriber's roaming number and routes the call to the visiting MSC. If not, it routes the call to the ISC of the home PLMN of the called subscriber.

CC	NDC	SN
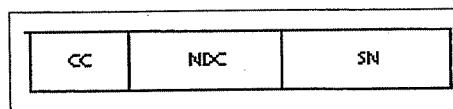
The structure for the GSM MSIS-

National Calls from Within the PLMN

When a local exchange (MSC) receives a call destined for a mobile, it queries the mobile's HLR for the roaming number of the mobile. On receipt of the MSRN, it routes the call to the called mobile's visiting MSC.

Addressing Other Components of a PLMN

Other components of a PLMN, which may be addressed for the routing of various signaling messages, are the MSCs, and the location registers. If these elements are addressed from within the same PLMN, the SS7 point codes (PC) can be used. Otherwise, for interPLMN routing, global titles (GT) derived, for instance, from the mobile country code (MCC) and the national destination codes (NDC) are used.

Radio Channel Structure in GSM

In GSM, the radio channels are based on a TDMA structure that is implemented on multiple frequency subbands (TDMA/FDMA). Each base station is equipped with a certain number of these preassigned frequency/time channels.

CEPT has made available two frequency bands to be used by the GSM system. These are: 890-915 MHz for the direction mobile to base station, and 935-960 MHz for the direction base station to mobile terminal. These bands are divided into 124 pairs of carriers spaced by 200 kHz, starting with the pair 890.2 MHz. Each cell site has a fixed assignment of a certain number of carriers, ranging from only one to usually not more than 15 channels. The cell ranges in size from 1 to several km.

The assigned spectrum of 200 kHz per channel is segmented in time by using a fixed allocation, time-division multiple access (TDMA) scheme. The time axis is divided into eight time slots of length 0.577 ms. The slots numbered from time slot 0 to 7 form a frame with length 4.615 ms. The recurrence of one particular time slot in each frame makes up one physical channel.

The TDMA scheme uses a gross bit rate of about 270 kb/s (with a Gaussian minimum shift keying modulation, GMSK) and requires sophisticated adaptive receiver techniques to cope with the transmission problems caused by multipath fading. The TDMA factor of 8 in combination with a carrier spacing of 200 kHz would correspond to the earlier analog system using single-channel per-carrier with a 25 kHz carrier spacing. The GSM digital system allowed operation at lower carrier to interference (C/I) ratio by using the gains provided by digital voice compression along with channel coding (powerful error correction). The reduced C/I ratio in turn allowed the use of shorter channel reuse distances to achieve spectrum efficiencies competitive to that achieved by the analog systems.

The TDMA structure is applied in both the forward (base station to mobile) and the reverse (mobile to base station) directions. The numbering, however, is staggered by three time slots, to prevent the mobile station from transmitting and receiving at the

same time. These time slots are used to carry user, and signaling or control information in bursts. The bursts are slightly shorter than the slots, namely .546 ms, to allow for burst timing alignment errors, delay dispersion on the propagation path, and for smooth switch on/off of the transmitter.

GSM defines a variety of traffic and signaling/control channels of different bit rates. These channels are assigned to logical channels derived from multiframe structuring of the basic eight slotted TDMA frames just discussed. For this purpose, two multiframe structures have been defined: one consisting of 26 time frames (resulting in a recurrence interval of 120 ms), and one comprising 51 time frames (or 236 ms).

The 26 multiframe is used to define traffic channels (TCH), and their slow and fast associated control channels (SACCH and FACCH) that carry link control information between the mobile and the base stations. The TCH have been defined to provide six different forms of services, that is, full-rate speech or data channels supporting effective bit rates of 13 kb/s (for speech), 2.4, 4.8, and 9.6 kb/s; and the half-rate channels with effective bit-rates of 6.5 (for speech) and kb/s, 2.4 kb/s, and 4.8 kb/s for data (note that the gross bit rates on these channels are higher due to required channel coding, 22.8 kb/s for full-rate speech). The full-rate TCHs are implemented on 24 frames of the multiframe, with each TCH occupying one time slot from each frame. The SACCH is implemented on frame 12 (numbered from 0), providing eight SACCH channels, one dedicated to each of the eight TCH channels. Frame 25 in the multiframe is currently idle and reserved to implement the additional eight SACCH required when half-rate speech channels become a reality. The FACCH is obtained on demand by stealing from the TCH, and is used by either end for signaling the transfer characteristics of the physical path, or other purposes such as connection handover control messages. The stealing of a TCH slot for FACCH signaling is indicated through a flag within the TCH slot.

The 51-frame multiframe has a more complex structure and we will refer the reader to GSM Recommendation 05.0 for the specific positions of the various logical channels in the multiframe. The 51-frame structure, however, is used to derive the following signaling and control channels.

SDCCH — Stand-alone dedicated control channel is used for the transfer of call control signaling to and from the mobile during call setup. Like the TCHs, the SDCCH has its own SACCH and is released once call setup is complete.

BCCH — Broadcast control channel is used in the BSS to mobile direction to broadcast system information such as the synchronization parameters, available services, and cell ID. This channel is continuously active, with dummy bursts substituted when there is no information to transmit, because its signal strengths are monitored by mobiles for handover determination.

SCH — Synchronization channel carries information from the BSS for frame synchronization.

FCCH — Frequency control channel carries information from the BSS for carrier synchronization.

CCCH — Common control channels are used for transferring signaling information between all mobiles and the BSS for call origination and call-paging functions. There are three common control channels:
- PCH: paging channel used to call (page) a mobile from the system.
- RACH: random access channel used by the mobiles trying to access the system. The mobiles use the slotted Aloha scheme over this channel for requesting a DCCH from the system at call initiation.
- AGCH: access grant channel used by the system to assign resources to a mobile such as a DCCH channel.

Note that the AGCH and the PCH are never used by a mobile at the same time, and therefore are implemented on the same logical channel. All the control signaling channels, except the SDCCH, are implemented on time slot 0 in different TDMA frames of the 51 multiframes using a dedicated RF carrier frequency assigned on a per cell basis. The multiframe structure for the SDCCH and its associated slow associated control channel (SACC) is implemented on one of the physical channels (TDM slots and RF carriers) selected by the system operator.

Mobility Management

Mobility management is concerned with the functions of tracking the location of roaming mobiles and registering the information in appropriate network elements, and handling connection handoffs for users in the communication process. These functions are discussed in the following sections.

Connection Handoffs

This may be done between channels in the same cell, between channels in different cells under the same BSS coverage, or between cells under the coverage of different BSSs, and even different MSCs. In GSM, the BSS may autonomously handle the connection handoffs in the same cell, or between cells under its own coverage. This is called internal connection handoffs. The MSC is involved in managing connection handoffs that need to take place between cells under coverage of two different BSSs. These are called external connection handoffs. When the BSS indicates that an external handover is required, the decision of when and whether an external handover should occur is then taken by the MSC. The MSC uses the signal quality measurement information reported by the mobile stations (MSs) which are pre-processed at the BSS for external handover determination.

The original MSC handling a call will always keep control of the call in an external handover to a different and even a subsequent MSC.

When the BSS performs an internal connection handoff, it informs the MSC at the completion of the process. The need for a connection handoff may be indicated by the mobile user, through messaging on the FACH, for instance, or by the BSS as it keeps tracking the quality of the signals received. The BSS monitors the quality of the radio signal received and also transmits such results to the MSC who keeps a more global view on the radio channels belonging to its BSSs. The

Common control channels are used for transferring signaling information between all mobiles and the BSS for call origination and call-paging functions.

A253
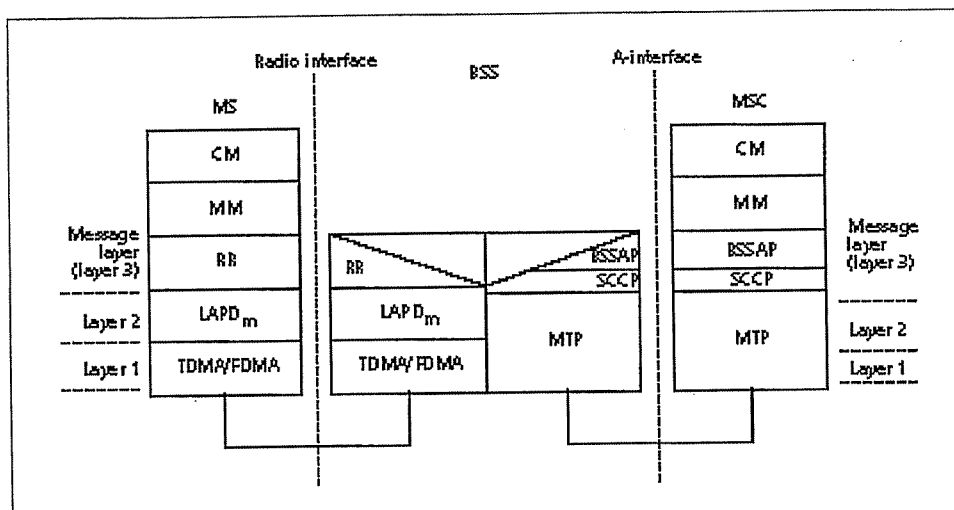
■   GSM protocol architecture.
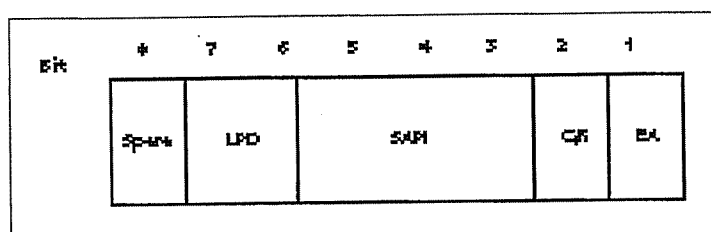
■   LAPDm "address field" format.

MSC may also initiate the need for a connection handoff for traffic reasons in an attempt to balance out the traffic load in the network.

Handling of Location Information

Location information is maintained and used by the network to locate the user for call routing purposes. The network registers the user's location in a register called the user's, HLR, which is associated with an MSC located in the PLMN, to which the user is subscribed. Each BSS keeps broadcasting, on a periodic basis, the cell identities on the "broadcast control channels" of the cells under its coverage. The mobiles within each cell keep monitoring such information. As changes in location are detected (from the last information recorded by them), they each report the new location to the BSS which routes it to the VLR, of the MSC to which it is connected. The VLR, in turn, sends the location information to the user's HLR, where it is also recorded. In the meantime, the HLR directs the old VLR to delete the old visiting location of the mobile from its data base, and also sends a copy of the user's service profile to the new VLR. Location updating is performed by the mobility management (MM) protocol sublayer that will be discussed later in the article.

Call Routing and Signaling

A call may be initiated by a mobile user to another mobile or a fixed landline user, or in reverse, by a fixed landline user to a mobile. For routing a call to a mobile user, however, the network signaling needs to first locate the mobile. We will illustrate this for the case when a call is initiated by a landline user,

and then comment on the scenario in which the call is initiated by a mobile to another mobile. When the call is initiated by a mobile to a landline user, the procedure is rather straightforward.

In the case of a call initiated by a landline user, the PSTN may use the mobile station ISDN number, MSISDN, to route the call to the closest Gateway MSC within the mobile's PLMN. The GMSC in turn uses the MSISDN to interrogate the mobile's HLR for the routing information required to extend the call to the visiting MSC of the mobile at the time. This visiting MSC (or more specifically the, VLR within the local MSC) is identified in the mobile's HLR by the MSRN which specifies the visiting MSC. The MSRN is a temporary number allocated by the VLR and sent to the HLR on location updating, or call initiation. The MSRN should have the same structure as the MSISDN numbers in the VLR area where it is allocated. The VLR then initiates the paging procedure and the MSC pages the mobile station with a paging broadcast to all BSSs of the location area, as the exact base station area of the mobile may not be known. After paging response, the current BSS is located. The RR and MM connections are established, during which both authentication of the user (for access to the network), as well as cipher mode setting are performed. The VLR then sends the required parameters for call setup to the MSC, and may also assign the mobile a new TMSI for the call. The MSC sends a setup message to the mobile station.

The mobile station, on receiving the set-up message performs a compatibility check and returns a call-confirmed message to the network, which may include the bearer capability of the mobile station. The BSS may at this point assign a traffic channel, TCH, to the call, or may assign it at a later stage, the latest being on receipt of the "connect message" from the mobile station. If user alerting is carried out at the MS, an alerting message is sent to the calling subscriber. When, the subscriber answers the call, the MS sends a connect message, which at the network side initiates the completion of the traffic channel allocation and switch through of the connection. The connect message is progressed to the calling subscriber. The network also sends an acknowledgement to the MS, that enters the active state.

Address field	Control field	Length indicator	Information field	fil bit

LAPDm general frame format.

LAPDm is a LAPD-like protocol that has been modified for operation within the constraints set by the radio pass.
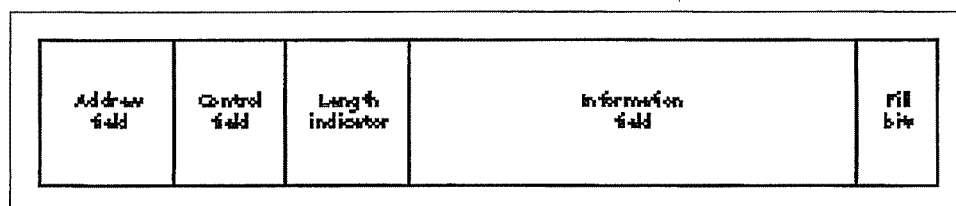
Protocol Layering Architecture

The GSM protocol architecture used for the exchange of signaling messages pertaining to mobility, radio resource, and connection management functions is shown in Fig. 3. The protocol layering consists of the physical layer, the data link layer, and the Layer 3. It is noted to the OSI-minded reader to be careful in not confusing the Layer 3 protocol functions defined by GSM with what is normally defined to be the Layer 3 functions in the OSI model. The GSM Layer 3 protocols are used for the communication of network resource, mobility, code format and call-related management messages between the various network entities involved. Since, in the OSI model, some of these functions are actually provided by the higher layers, the term "message layer" may be a more appropriate term for refering to the Layer 3 in GSM. The message layer (Layer 3) protocol is made up of three sublayers called the resource management (RR) implemented over the link between the MS and the BSS, the mobility management (MM), and connection management (CM) sublayers providing the communication between the MS and the MSC. Layer 3 also implements the message transport part (MTP), level 3, and the signaling connection control part of the CCITT SS7 on the link between the BSS and the MSC (the A interface) to provide the transport and addressing functions for signaling messages belonging to the various calls routed through the MSC. In discussing the functionality provided by the Layer 3 in the GSM protocol stack, particular attention should be paid to not confuse the details of this layer's functionality with what is commonly provided by the Layer 3 of the OSI protocol stack. In GSM, the CM, and MM sublayers, for instance, provide actually some of the functionalities which are realized by the transport, the session, and the presentation layers of OSI, as will be seen later. The functions of each protocol layer/sublayer is discussed in some detail in the following.

Physical Layer

The physical layer on the radio link was discussed in the section on radio channel structure. The traffic channels on the landside are formed from TDM slots implemented on 2.048 Mb/s links (E1 trunks). The signaling channels are basically logically multiplexed on an aggregate of the TDM slots.

Link Layer on the Air Interface

The data link layer over the radio link (connecting the MS to the BSS) is based on a LAPD-like protocol, labeled LAPDm, that has been modified for operation within the constraints set by the radio path. In particular, LAPDm uses no flags (and therefore no bit stuffing) for frame delim-

itation. Instead, frame delimitation in LAPDm is done by the physical layer that defines the transmission frame boundaries. LAPDm uses a "Length Indicator" field to distinguish the information carrying field from fill-in bits used to fill the transmission frame. LAPDm uses an address field to carry the service access point identifier, (SAPI), (3 bits in this case) which LAPD also uses to identify the user of the service provided by the protocol. When using command/control frames, the SAPI identifies the user for which a command frame is intended, and the user transmitting a response frame. The format for the address field is shown in Fig. 4. The 2-bit link protocol discriminator (LPD) is used to specify a particular recommendation of the use of LAPDm, the C/R is a single bit which specifies a command or response frame as used in LAPD, and a 1-bit extended address (EA) is used to extend the address field to more than one octet (the EA bit in the last octet of the address should be set to 1, otherwise to 0). The 8-bit is reserved for future uses.

LAPDm uses a control field as is used in LAPD to carry sequence numbers, and to specify the type of frame. LAPDm uses three types of frames used for supervisory functions, unnumbered information transfer and control functions (unacknowledged mode), and numbered information transfer (multiframe acknowledged mode) as used in LAPD. LAPDm uses no cyclic redundancy check bits for error detection. Error correction and detection mechanisms are, instead, provided by a combination of block and convolutional coding used (in conjuction with bit interleaving) in the physical layer. The general frame format for LAPDm is shown in Fig. 5.

Link Layer on the A Interface

On the terrestrial link connecting the BSS to the MSC (the A interface), the MTP level 2 of the SS7 protocol is used to provide the OSI Layer 2 functions of reliable transport for the signaling messages, such as recovery from transmission errors through error detection and retransmission.

Message Layer Protocols and Functions

Radio Resource (RR) Management Sublayer

The RR management sublayer terminates at the BSS and performs the functions of establishing physical connections over the radio for the purpose of transmitting call-related signaling information such as the establishment of signaling and traffic channels between a specific mobile user and the BSS. The RR management functions are basically implemented in the BSS.

Location updating is the procedure for keeping the network informed of where the mobile is roaming.

Mobility Management Sublayer (MM)

The MM sublayer is terminated at the MSC and the related messages from or to the MS are relayed transparently in the BSS using the DTAP process. The MM sublayer provides functions that can be classified into three types of procedures. These are called the MM specific procedures, the MM common procedures, and the MM connection-related procedures. These procedures are discussed in the following.

MM Connection Related Procedures

These are the procedures used to establish, maintain, and release a MM connection between the MS and the network (MSC) over which an entity of the connection management (CM) sublayer can exchange information with its peer. More than one MM connection may be active at the same time to serve multiple CM entities. Each CM entity within the MS will have its own MM connection, and each connection is identified by the protocol discriminator, and a transaction identifier within the related signaling messages exchanged. The transaction identifier is sort of analogous to the call reference used by ISDN to identify signaling messages from different calls on the D channel. Thus parallel calls can be supported by the same MS which are then identified by a different value for the transaction identifier parameter. Establishment of a MM connection requires that no MM-specific procedure (discussed later) be active.

The MM connections provide services to the different entities of the upper connection management (CM) sublayer which currently consist of the call control (CC), the short message services (SMS), and the call-independent supplementary services (SS). An MM connection is initiated by a CM service request message which identifies the requesting CM entity and the type of service required of the MM connection. The services provided by the MM connections include such things as enciphering (for privacy of user information), and authentication (of the users-access to the network and the service requested) which would be actually provided by the presentation, and application layers in the OSI framework. Each of these services would involve the exchange of multiple messages between the MS and the network before the required MM connection is established and the requesting entity within the CM sublayer is notified.

Mobility Management Specific Procedures

The MM specific procedures do not set up an MM connection. They can only be initiated when no other MM-specific procedure is running, and no MM connection is established. These procedures consist of location updating, and the IMSI attach procedures. These are discussed in the following.

Location Updating

Location updating is the procedure for keeping the network informed of where the mobile is roaming. Location updating is always initiated by the mobile station on either detecting that it is in a new location area by periodically monitoring the location information broadcast by the network on the broadcast channel, and comparing it to the information previously stored in its memory, or by receiving an indication from the network that it is not known in the VLR upon trying to establish an MM connection. Anytime, the network updates the mobile's location, it sends it an updated "temporary mobile subscriber identification" (TMSI), in ciphered mode, which is stored in the MS and used for subsequent mobile identification in paging and call initiating operations. The purpose of using the TMSI as opposed to the user's IMSI is to keep the subscriber's identity confidential on the radio link. The TMSI has no GSM-specific structure, and has significance only within the location area assigned. The TMSI has to be combined with the location area identifier (LAI) to provide for unambiguous identification outside the area where it is assigned.

IMSI Attach

The IMSI attach procedure is the complement of the IMSI detach procedure, a function of the MM common procedures (discussed later). Both of these procedures are network options whose necessity of usage are indicated through a flag in the system information broadcast on the BCCH channel. The IMSI detach/attach procedures mark the MS as detached/attached in the VLR (and optionally in the HLR) on MS power down or power up or subscriber information module (SIM) removed or inserted (The IMSI detach disables the location updating function to prevent unnecessary signaling overhead on the network). Any incoming calls, in that case, are either rejected or forwarded as may be specified by the user). The IMSI is used to indicate the IMSI as active in the network. This procedure is invoked if an IMSI is activated in a MS (power up, or SIM insertion) in the coverage area of the network, or an activated MS enters the network's coverage area from outside. The IMSI attach procedure is then performed only if the stored location area at the time is the same as the one being broadcast on the BCCH channel of the serving cell. Otherwise, a normal location updating procedure is invoked regardless of whether the network supports IMSI attach/detach procedures.

MM Common Procedures

The MM common procedures can be initiated at any time while a dedicated radio channel exists between the network and the MS. They do not set up an MM connection, but can be initiated during an MM specific procedure, or while an MM connection is in place. The MM Common procedures consist of IMSI detach, TMSI reallocation, and authentication/identification. These are discussed next.

IMSI Detach

The IMSI detach procedure is invoked by the mobile station to indicate inactive status to the network. No response or acknowledgement is returned to the MS by the network on setting the active flag for the IMSI.

The IMSI detach procedure is not started if at the time a MM-specific procedure is active. In that case, the IMSI detach procedure is delayed, if possible until the MM-specific procedure is finished, otherwise the IMSI detach request is omitted.

If at the time of a detach request, a radio connection is in existence between the MS and the network, the MM sublayer will release any ongoing MM connections before the MM detach indication message is sent.

TMSI Reallocation

The purpose of TMSI reallocation is to provide identity confidentiality. That is, to protect the user from being identified and located by an intruder. This procedure must be performed at least at each change of the MSC coverage area. Reallocation in any other case is left to the network operator.

If the TMSI provided by a mobile station is unknown in the network, for instance, in the case of a data base failure, the MS has to provide its IMSI on request from the network. In this case the identification procedure has to be performed before the TMSI procedure can be initiated.

Authentication

The purpose of the authentication procedure is to let the network verify the identity provided by the user when requested, and to provide a new ciphering key to the mobile station. The cases when authentication procedures should be used are defined in GSM Recommendation 02.09. The authentication procedure is always initiated and controlled by the network.

Identification

This procedure is used by the network to request a mobile station to provide specific identification parameters to the network, such as the user's international mobile subscriber or equipment identifiers (IMSI or IMEI). The mobile station should be ready to respond to an identity request message at any time while RR connection exists between the mobile and the network.

Connection Management Sublayer (CM)

The CM sublayer terminates at the MSC and contains entities that currently consist of CC including call-related supplementary services, SMS, and call independent supplementary services support (SS). Once a MM connection has been established, the CM can use it for information transfer. The CC entity uses the CCITT Q.931 protocol, with minor modifications, for the communication of call control-related messages between the MS and the MSC. The SMS is a GSM-defined service that provides for speedy packet mode ("connectionless") communication of messages up to 140 bytes between the MS and a third party service center. These messages can be sent or received by the mobile station while a voice or data call is in the active or inactive state. It is acceptable, however, if the service is aborted while a call is in a transitional state such as handover or busy-to-idle. The service center is responsible for the collection, storage, and delivery of short messages, and is outside the scope of GSM.

BSS Application Part (BSSAP)

The BSS, in addition to providing the channel switching and aerial functions, performs radio resource management, and interworking functions between the data link protocols used on the radio and the BSS-MSC side for transporting signaling-related messages. These functions are provided by the BSS Management Application Process (BSSMAP), and the Direct Transfer Application Process (DTAP).

The BSSMAP is used to implement all procedures between the MSC and the BSS that require interpretation and the processing of information related to single calls, and resource management. Basically, the BSSMAP is the process within the BSS that controls radio resources in response to instructions from the MSC (in that sense, the BSSMAP represents the RR sublayer to the MSC). For instance, the BSSMAP is used in the assignment and switching of radio channels at call setup, and handover processes.

The DTAP process is used for the transparent transfer of MM/CM signaling messages between the MS and the MSC. That is, the DTAP function provides the transport level protocol interworking function for transferring Layer 3 signaling messages from and to the MS to and from the MSC without any analysis of the message contents.

Signaling Transport Protocols

The CCITT SS7 MTP and SCCP protocols are used to implement both the data link and the Layer 3 transport functions for carrying the call control and mobility management signaling messages on the BSS-MSC link. The MM and CM sublayer signaling information from the mobile station is routed over signaling channels (such as the DCCH, SACCH, FACCH) to the BSS from where they are transparently relayed through the DTAP process to an SCCP, of CCITT SS7 type logical channel, assigned for that call, on the BSS-MSC link for transmission to the peer CC entity in the MSC for processing. Similarly, any call signaling information initiated by the MSC on the SCCP connection is relayed through the DTAP process in the BSS to the assigned signaling channel, using the LAPDm data link protocol, for delivery to the mobile station.

The interworking between the Layer 2 protocol on the radio side and the SS7 on the BSS-MSC link is provided by a distribution data unit within the information field of the SCCP. These parameters are known as the discrimination, and the data link connection identifier (DLCI) parameters. The discrimination parameter (currently dedicated one octet) uses a single bit to address a message either to the DTAP or the BSSMAP processes. The DLCI parameter (sized one octet) is made up of two subparameters that identify the radio channel type (such as the DCCH, SACCH, FACCH), and the "Service Access Point Interface" (SAPI) value (in the LAPDm protocol) used for the message on the radio link. The SCCP provides for the logical multiplexing of signaling information from different calls onto the same physical channel (such as a single 64 kb/s slot of a 2.048 Mb/s E1 trunk) on the BSS-MSC link. For each call supported by a BSS, an SCCP logical connection is established on the BSS-MSC link. Any information pertaining to a specific call flows through its associated SCCP connection and that is how signaling information exchange pertaining to different calls are identified in the BSS or MSC.

The connectionless service mode of the SCCP is also supported for the transfer of OA&M related messages as well as BSSMAP messages that do not pertain to any specific call (Note that BSSMAP messages pertaining to specific calls, such as hand-off messages, are transmitted using the SCCP connection established for the call). The SCCP routing function uses the SubSystem Number (SSN)

The authentication procedure allows the network to verify the identity provided by the user when requested, and to provide a new ciphering key to the mobile station.

The optimum size for the paging area is determined by a proper balance between the costs of paging and the costs of location updates.

in the Service Information Octet (SIO) within the MTP level 3 message to distinguish messages addressed to the OA&M function from those addressed to either the DTAP or the BSSMAP application parts. The high-level address translation capability of the SCCP, known as global title translation, may then be used to provide additional addressing capabilities such as use of E.164 numbering for addressing different OA&M entities. The global title translation feature of the SCCP also provides the MSC the capability to address signaling messages to remote MSCs that may be located in a different PLMN.

The interworking functions between the CM, MM and BSSMAP entities and the corresponding entities of the SS7 (i.e., the ISDN-UP), MAP, SCCP, and the transactions capabilities application part (TCAP) is provided by the MSC.

Paging

Paging messages for mobiles are sent via the BSSMAP to the BSS as a connectionless message through the SCCP/MTP. The paging message may include the mobile's IMSI in order to allow derivation of the paging population number. A single paging message transmitted to the BSS may contain a list of cells in which the page is to be broadcast. The larger the paging area is defined, the lower the frequency of location updates and hence the associated traffic overhead on the network. On the other hand, large paging areas result in increased use of transmitting power as well as the radio resources (channels). Therefore, the optimum size for the paging area (location area) is determined by a proper balance between the costs of paging and the costs of location updates.

The paging messages received from the MSC are stored in the BS, and corresponding paging messages are transmitted over the radio interface at the appropriate time. Each paging message relates to only one mobile station and the BSS has to pack the pages into the relevant 04.08 paging message (include Layer 3 information). Once a paging message is broadcast over the radio channel(s), if a response message is received from the mobile, the relevant signaling connection is set up towards the MSC and the page response message is passed to the MSC.

Summary Remarks

The description of the GSM network functions, system architecture and protocols are spread over a large number of GSM documents, each of which contains many details with some of the critical issues and highlights covered within those details. Therefore, it is not an easy task to extract out some of the crucial concepts and design specifics,

and present it in some logical and well-related format. I have tried my best, however, to achieve this goal in this article.

This article was meant to provide a concise, brief, but adequately detailed description of the GSM system and protocol architecture that can serve as a quick, rather self-contained conceptual framework for extending and relating the mobility-specific functions of the next generation personal communication networks to the GSM network functions, and the protocols used to achieve them. Finally, a list of references have been provided for any more detailed information on the issues addressed in the article.

Acknowlegements

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Biography

MOE RAHNEMA received a B.S. degree in engineering science from the University of Kentucky at Lexington in 1978 with honors. He received the M.S. degree and the more advanced engineering degree in Avionics from MIT in 1981. From 1983 to 1984, he taught and studied communication sciences at Northeastern University from which he also received the Engineer degree in electrical and computer engineering with Ph.D-level coursework. He worked as a senior communication design engineer at Infinet in Andover, Mass from 1984 to 1985, where he designed the digital signal processing firmware for a 4800 baud modem. From 1985 to 1989, he worked as a member of the technical staff at GTE Laboratories, and developed a new system architecture for fast packet switching based on the slotted ring concept (published in IEEE Transactions on Communications, April 1990). From 1989 to 1991, he worked as a principal engineer at Arinc on the design and analysis of air/ground communication networks for the airlines industry. He joined Motorola as a principal communication engineer in 1992, and since has been working on the Iridium satellite project. His interests include wireless networks, communication systems, and digital signal processing.

Page 1

1   UNITED STATES DISTRICT COURT

2   FOR THE DISTRICT OF DELAWARE

3   TRUEPOSITION,   )
)
4   Plaintiff/   )
         Counterclaim-Defendant,   )
5   )
             vs.   )   No. 05-00747-SLR
6   )
     ANDREW CORPORATION,   )
7   )
         Defendant/   )
8   Counterclaim-plaintiff.   )

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13   VIDEOTAPED DEPOSITION OF CURTIS A. KNIGHT, PH.D.
                  Oakland, California
14   Friday, October 6, 2006

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     Reported By:
24   MARY F. NELSON
     CSR No. 3553
25   Job No. 191687

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1   A   Yes.
2   Q   Dr. Knight, can you we turn to Fig. 8A of the
3   patent? Are you there?
4   A   Yes.
5   Q   "Step 1, Obtain correlations." Is this the
6   process for actually performing the correlation
7   function?
8   MR. HEIST: Object to form.
9   THE WITNESS: No, that occurs in 8B. I'm
10   sorry, I take it back. Would you repeat that question,
11   please?
12   MS. WALDRON: I'm sorry, court reporter, could
13   you please read it back?
14   (Record read.)
15   MR. HEIST: Object to form.
16   THE WITNESS: Yes, that occurs in a square box
17   in the lower left, third box from the bottom.
18   BY MS. WALDRON:
19   Q   Are you referring to, "Set correlator input
20   data B to another cell site's data, leaving A on the
21   site with power detection"?
22   THE WITNESS: Yes.
23   BY MS. WALDRON:
24   Q   Dr. Knight, how does Fig. A relate to Fig. 7,
25   if at all?

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1   MR. HEIST: Referring to 7 or 7A?
2   MS. WALDRON: 7.
3   MR. HEIST: 7.
4   THE WITNESS: Fig. 8A would be understood as an
5   amplification view, a detail view of Fig. 7 and second
6   block down from the top.
7   BY MS. WALDRON:
8   Q   What about the second block down from the top?
9   A   Second block down from the top of Fig. 7.
10   Q   So you're saying that the block in Fig. 7
11   labeled "Cross-Correlate data" corresponds to Fig. 8A?
12   A   Yes.
13   Q   Are there any -- Dr. Knight, how does Fig. 8B
14   relate to Fig. 7, if at all?
15   A   Fig. 8B would be the "Calculate TDOA data" step
16   in Fig. 7.
17   Q   Dr. Knight, how if at all does Fig. 8C relate
18   to Fig. 7?
19   A   Fig. 8C and for that matter Fig. 8D are
20   incorporated in the "Calculate lat., long. for each
21   signal" block of Fig. 7.
22   Q   I notice that Fig. 8D seems to continue to
23   Fig. 8E?
24   A   Yes.
25   Q   Is Fig. 8E also included in "Calculate lat.,

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1   long. for each signal"?
2   A   Yes.
3   Q   So the box on Fig 7 labeled "Calculate lat.,
4   long. for each signal," corresponds to Figs. E -- I'm
5   sorry, Fig. 8C, Fig. 8D and Fig. 8E?
6   A   Yes, except in Fig. 8 there is also a velocity,
7   a velocity calculation indicated. It doesn't obviously
8   appear in Fig. 7.
9   Q   So it looks like actually the last half of 8D
10   and Fig. 8E pertain to velocity?
11   A   Yes.
12   Q   So it's really Fig. 8C and the first half of
13   8D that pertains to "Calculate lat., long. for each
14   signal" of Fig. 7?
15   A   Yes.
16   Q   Dr. Knight, could you please turn to figure --
17   I'm sorry, Column 9, of the 144 patent?
18   A   Yes.
19   Q   Do you see under the heading "Cell Site
20   Systems" at approximately Line 40 -- I'm sorry, at
21   Line 48 there is a sentence that begins, "The first
22   embodiment"?
23   A   Yes.
24   Q   It says:
25   "The first embodiment is the most

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1   preferred embodiment and comprises [and
2   then it goes on to say] (1) an
3   antenna...; [skipping down] (2) a low
4   delay band pass filter...; (3) an
5   amplifier...; (4) a set of...twenty-one
6   individual low delay band pass
7   filters...; and (5) a set of twenty-one
8   automatic gain control circuits..."
9   Do you see that?
10   A   Yes.
11   Q   And then at Line 63 of Column 9 it says:
12   "This embodiment is preferred
13   because of its superior interference
14   discrimination and rejection."
15   A   Yes.
16   Q   What about the embodiment described at
17   Lines 48 through 63 confers the characteristic of
18   superior interference discrimination and rejection?
19   A   The filtering. A combination of the filters.
20   Q   Which steps -- I'm sorry, which components of
21   the ones labeled 1 through 5 are you referring to when
22   you say the filtering?
23   A   The low delay band pass filter.
24   Q   No. 4?
25   A   Yes.

28 (Pages 106 to 109)

A260

John Webber   October 4, 2006

Page 1

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF DELAWARE

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TruePosition, Inc.              )
     Plaintiff/                 )
     Counterclaim-Defendant,    )
                                )  Civil Action No.
vs.                             )  05-00747-SLR
                                )
Andrew Corporation,             )
     Defendant/                 )
     Counterclaim-Plaintiff.    )
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October 4, 2006

        The deposition of JOHN C. WEBBER, taken at the

instance of the Defendant, before Carolyn M.

O'Connor, RMR, CRR, CCR, a Notary Public for the

Commonwealth of Virginia at Large, beginning at 9:04

a.m., at the Marriott Courtyard, 1201 West Main

Street, Charlottesville, Virginia; said deposition

taken pursuant to the Federal Rules of Civil

Procedure.

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John Webber   October 4, 2006

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1   "Step 2, Obtain Delays and Frequency Differences,"
2   also be a software program that is on a standalone
3   computer?
4   MR. MILCETIC: Objection.
5   You can answer.
6   A   Yes, it could be in a separate computer
7   from that of Step 1, or it could be a different
8   thread running within one particular machine,
9   depending on the computational ability of a
10   particular computer or computers that are chosen.
11   Q   Turning the page to Figure 8C, "Step 3,
12   Estimate Location," am I correct that Figure 8C also
13   refers to -- I'm sorry, depicts steps executed by
14   software?
15   A   Yes.
16   Q   Would this software also reside on a
17   standalone computer?
18   MR. MILCETIC: Objection.
19   You can answer.
20   A   Yes, it could reside in the same computer
21   performing Steps 1 and 2 or in a separate computer,
22   depending on the computational ability of the
23   hardware.
24   Q   Dr. Webber, turning the page to
25   Figure 8D, am I correct that Figure 8D also

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1   represents steps being executed by software?
2   A   Yes, although if you look at it, you'll
3   see that Figures 8D and 8E are linked by arrows that
4   go both up and down, so Figures 8D and E should be
5   considered one step of data processing, and the
6   answer is that all of these are performed in a
7   computer -- general-purpose computer, which could be
8   the same or different hardware from that doing the
9   preceding steps.
10   Q   So to make sure I understand correctly,
11   is it the case, then, that Figure 8C, Figure 8D and
12   Figure 8E are all a part of depicting "Step 3,
13   Estimate Location"?
14   MR. MILCETIC: Objection.
15   You can answer it.
16   A   No, there are independent steps in
17   Figure 8A. Step 1 is a standalone. It has a
18   certain amount of inputs and a set of outputs, and
19   it does not interact with subsequent data
20   processing.
21   Q   Okay.
22   A   Figure 8B, Step 2, also has a set of
23   inputs and a set of outputs, and that process
24   operates independently of the other steps. It has
25   no feedback from anywhere else.

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1   "Step 3, Estimate Location" --
2   Figures 8C, 8D and 8E are all linked. There's
3   feedback shown from Figure 8E to Figure 8D, but all
4   of this information flows through to the final box
5   in Figure 8E before the "Done," namely "Output Phone
6   Information, Best Latitude, Best Longitude, Best
7   Speed, Best Direction." So Figures 8C, D and E are
8   all part of the same process and are linked together
9   so that they would typically be performed all as
10   part of one program operating in one general-purpose
11   computer.
12   Q   So where -- if I understand correctly,
13   figuring out the latitude, longitude, speed and
14   direction are all linked in this step. What portion
15   of Figure 8C depicts figuring out latitude and
16   longitude?
17   A   That page of Figure 8C and the top part
18   of Figure 8D are linked. You'll see that at the
19   beginning of Figure 8D, there are still references
20   to latitude and longitude until the box
21   approximately in the middle of the page that says
22   "Set Speed to Zero." At the point in processing
23   where it says "Set Speed to Zero," the latitude and
24   longitude have been estimated, and that calculation
25   is complete, but the speed and direction have not

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1   been completed.
2   Q   I understand.
3   MS. WALDRON: I think we need to change
4   the tape.
5   THE VIDEOGRAPHER: It is approximately
6   3:17 p.m. We are off the record.
7
8   (Break taken.)
9
10   THE VIDEOGRAPHER: We are on the record.
11   It is approximately 3:23 p.m. Counsel may
12   resume.
13
14   EXAMINATION BY MS. WALDRON: (Cont'g)
15   Q   Dr. Webber, before we went off the record
16   to change the tape, I believe you said that the
17   portion of Figure 8C and 8D that correspond to
18   calculating the location are the entire page of
19   Figure 8C and the top half of the page of Figure 8D
20   going down to the box called "Set Speed to Zero"; is
21   that correct?
22   A   That's correct.
23   Q   With regard to the first box of
24   Figure 8C, Get Observed Delays, Frequencies" --
25   A   Uh-huh.

42 (Pages 162 to 165)

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Merriam-Webster's Collegiate® Dictionary

TENTH EDITION

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Springfield, Massachusetts, U.S.A.

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birl • biting   117

birl \'bər(-ə)l, *Scot also* 'bir(-ə)l\ *vi* [ME fr. OE *byrelian*; prob. akin to OE *beran* to carry — more at BEAR] (ca. 1585) *chiefly Scot* : CAROUSE

birl *vb* [perh. imit.] *vt* (1790) 1 : SPIN 2 : to cause (a floating log) to rotate by treading ~ *vi* : to progress by whirling — **birl·er** \'bər-lər, 'bir-\ *n*

Bi·ro \'bī-(,)rō\ *trademark* — used for a ballpoint pen

birr \'bər, 'bir\ *n, pl* **birr** [Ar] (ca. 1978) — see MONEY table

birse \'birs, 'bərs\ *n* [(assumed) ME *birst*, fr. OE *byrst* — more at BRISTLE] (bef. 12c) 1 *chiefly Scot* : a bristle or tuft of bristles 2 *chiefly Scot* : ANGER

birth \'bərth\ *n, often attrib* [ME, fr. ON *byrth*; akin to OE *beran*] (13c) 1 a : the emergence of a new individual from the body of its parent b : the act or process of bringing forth young from the womb 2 : a state resulting from being born esp. at a particular time or place ⟨a Southerner by ~⟩ 3 a : LINEAGE, EXTRACTION ⟨marriage between equals in ~⟩ b : high or noble birth 4 *archaic* : one that is born 5 : BEGINNING, START ⟨the ~ of an idea⟩

birth *vt* (1906) 1 *chiefly dial* : to bring forth 2 : to give rise to : ORIGINATE ~ *vi* : to bring forth a child or young

birth canal *n* (1927) : the channel formed by the cervix, vagina, and vulva through which the fetus passes during birth

birth certificate *n* (1900) : a copy of an official record of a person's date and place of birth and parentage

birth control *n* (1914) : control of the number of children born esp. by preventing or lessening the frequency of conception : CONTRACEPTION

birth·day \'bərth-,dā\ *n* (14c) 1 a : the day of a person's birth b : a day of origin 2 : an anniversary of a birth ⟨her 21st ~⟩

birthday suit *n* (1753) : unclothed skin : NAKEDNESS

birth defect *n* (1971) : a physical or biochemical defect that is present at birth and may be inherited or environmentally induced

birth·mark \'bərth-,märk\ *n* (1580) : an unusual mark or blemish on the skin at birth : NEVUS

birth pang *n* (ca. 1887) 1 : one of the regularly recurrent pains that are characteristic of childbirth — usu. used in pl. 2 *pl* : disorder and distress incident esp. to a major social change

birth·place \'bərth-,plās\ *n* (1607) : place of birth or origin

birth·rate \'bərth-,rāt\ *n* (1859) : the ratio between births and individuals in a specified population and time

birth·right \'bərth-,rīt\ *n* (1535) : a right, privilege, or possession to which a person is entitled by birth

birth·root \'bərth-,rüt, -,rut\ *n* (1822) : any of several trilliums with astringent roots used in folk medicine

birth·stone \'bərth-,stōn\ *n* (1907) : a gemstone associated symbolically with the month of one's birth

birth·wort \-,wort, -,wȯrt\ *n* (1551) : any of several herbs or woody vines (genus *Aristolochia* of the family Aristolochiaceae, the birthwort family) with aromatic roots used in folk medicine to aid childbirth

bis \'bis\ *adv* [L, fr. OL *dvis*; akin to OHG *zwiro* twice, L *duo* two — more at TWO] (1819) 1 : AGAIN — used in music as a direction to repeat 2 : TWICE

Bi·sa·yan \bə-'sī-ən\ *n* [Bisayan *Bisayd*] (1951) 1 : a member of any of several peoples in the Visayan islands, Philippines 2 : the group of Austronesian languages of the Bisayans

bis·cuit \'bis-kət\ *n, pl* **biscuits** *also* **biscuit** [ME *bisquite*, fr. MF *bescuit*, fr. (pain) *bescuit* twice-cooked bread] (14c) 1 a : any of various hard or crisp dry baked products: as (1) *Brit* : CRACKER (2) *Brit* : COOKIE b : a small quick bread made from dough that has been rolled out and cut or dropped from a spoon 2 : earthenware or porcelain after the first firing and before glazing 3 a : a light grayish yellowish brown b : a grayish yellow

bi·sect \'bī-,sekt, bī-'\ *vb* ['bi- + *intersect*] *vt* (ca. 1645) 1 : to divide into two usu. equal parts ~ *vi* : CROSS, INTERSECT — **bi·sec·tion** \'bī-,sek-shən, bī-'\ *n* — **bi·sec·tion·al** \-shnəl, -shə-nᵊl\ *adj* — **bi·sec·tion·al·ly** *adv*

bi·sec·tor \'bī-,sek-tər, bī-'\ *n* (1864) : one that bisects; esp : a straight line that bisects an angle or a line segment

bi·sex·u·al \(,)bī-'sek-sh(ə-)wəl, -shəl\ *adj* (1824) 1 a : possessing characters of both sexes : HERMAPHRODITIC b : sexually oriented toward both sexes 2 : of, relating to, or involving both sexes — **bisex·ual** *n* — **bi·sex·u·al·i·ty** \,bī-,sek-shə-'wa-lə-tē\ *n* — **bi·sex·u·al·ly** \(,)bī-'sek-sh(ə-)wə-lē, -shə-lē\ *adv*

bish·op \'bi-shəp\ *n* [ME *bisshop*, fr. OE *biscop*, fr. LL *episcopus*, fr. Gk *episkopos*, lit., overseer, fr. *epi-* + *skeptesthai* to look — more at SPY] (bef. 12c) 1 : one having spiritual or ecclesiastical supervision: as a : an Anglican, Eastern Orthodox, or Roman Catholic clergyman ranking above a priest, having authority to ordain and confirm, and typically governing a diocese b : any of various Protestant clerical officials who superintend other clergy c : a Mormon high priest presiding over a ward or over all other bishops and over the Aaronic priesthood 2 : either of two pieces of each color in a set of chessmen having the power to move diagonally across any number of adjoining unoccupied squares 3 : mulled port wine flavored with roasted oranges and cloves

bish·op·ric \'bi-shə-(,)prik\ *n* [ME *bisshopriche*, fr. OE *bisceoprice*, fr. *bisceop* + *rice* kingdom — more at RICH] (bef. 12c) 1 : DIOCESE 2 : the office of bishop 3 : the administrative body of a Mormon ward consisting of a bishop and two high priests as counselors

Bishops' Bible *n* (1835) : an officially commissioned English translation of the Bible published in 1568

bis·muth \'biz-məth\ *n* [NL *bismuthum*, modif. of G *Wismut*] (1668) : a heavy brittle grayish white chiefly trivalent metallic element that is chemically like arsenic and antimony and that is used in alloys and pharmaceuticals — see ELEMENT table — **bis·mu·thic** \biz-'mə-thik, -'myü-\ *adj*

bi·son \'bī-sᵊn, -zᵊn\ *n, pl* **bison** [L *bisont-, bison*, of Gmc origin; akin to OHG *wisunt* aurochs; akin to OPruss *wissambrs* aurochs] (1611) : any of several large shaggy-maned usu. gregarious recent or extinct bovine mammals (genus *Bison*) having a large head with short horns and heavy forequarters surmounted by a large fleshy hump: as a : WISENT b : BUFFALO 1c(1) — **bi·son·tine** \-sᵊn-,tīn, -zᵊn-\ *adj*

bisque \'bisk\ *n* [F] (1647) 1 a : a thick cream soup made with shellfish or game b : a cream soup of pureed vegetables 2 : ice cream containing powdered nuts or macaroons

bisque *n* [F] (ca. 1656) : odds allowed an inferior player: as a : a point taken when desired in a set of tennis b : an extra turn in croquet c : one or more strokes off a golf score

bisque *n* [by shortening & alter.] (1664) : BISCUIT 2; esp : unglazed china that is not to be glazed but is hard-fired and vitreous

bi·state \'bī-,stāt\ *adj* (1928) : of or relating to two states

bis·ter *or* **bis·tre** \'bis-tər\ *n* [F *bistre*] (ca. 1751) 1 : a yellowish brown to dark brown pigment used in art 2 : a grayish to yellowish brown — **bis·tered** \-tərd\ *adj*

bis·tort \'bis-,tȯrt, bis-'\ *n* [MF *bistorte*, fr. (assumed) ML *bistorta*, fr. L *bis* + *torta*, fem. of *tortus*, pp. of *torquēre* to twist — more at TORTURE] (1578) : any of several polygonums; esp : a European herb (*Polygonum bistorta*) or a related American plant (*P. bistortoides*) with twisted roots used as astringents

bis·tro \'bēs-(,)trō, 'bis-\ *n, pl* **bistros** [F] (1921) 1 : a small or unpretentious restaurant 2 a : a small bar or tavern b : NIGHTCLUB — **bis·tro·ic** \bēs-'trō-ik, bis-\ *adj*

bi·sul·fate \(,)bī-'səl-,fāt\ *n* (ca. 1846) : an acid sulfate

bi·sul·fide \-,fīd\ *n* [ISV] (1863) : DISULFIDE

bi·sul·fite \-,fīt\ *n* [F, fr. *bi-* + *sulfite*] (ca. 1846) : an acid sulfite

bi·swing \'bī-'swiŋ\ *adj* ['bi- + *swing*; perh. fr. the freedom of movement allowed by this jacket] (1968) : made with a pleat or gusset at the back of the arms ⟨~ jacket⟩

bit \'bit\ *n* [ME *bite*, fr. OE *bite* act of biting; akin to OE *bītan*] (14c) 1 a (1) : the biting or cutting edge or part of a tool (2) : a replaceable part of a compound tool that actually performs the function (as drilling or boring) for which the whole tool is designed b *pl* : the jaws of tongs or pincers 2 : something bitten or held with the teeth a : the usu. steel part of a bridle inserted in the mouth of a horse b : the rimmed mouth end on the stem of a pipe or cigar holder 3 : something that curbs or restrains 4 : the part of a key that enters the lock and acts on the bolt and tumblers

bit *vt* **bit·ted; bit·ting** (1583) 1 a : to put a bit in the mouth of (a horse) b : to control as if with a bit 2 : to form a bit on (a key)

bit *n* [ME, fr. OE *bita*; akin to OE *bītan*] (bef. 12c) 1 : a small quantity of food; esp : a small delicacy 2 a : a small piece or quantity of some material thing b (1) : a small coin (2) : a unit of value equal to ⅛ of a dollar ⟨four ~s⟩ 3 : something small or unimportant of its kind: as a : a brief period : WHILE b : an indefinite usu. small degree, extent, or amount ⟨a ~ of a rascal⟩ ⟨every ~ as powerful⟩ c (1) : a small part usu. with spoken lines in a theatrical performance (2) : a usu. short theatrical routine ⟨a corny comedy ~⟩ 4 : the aggregate of items, situations, or activities appropriate to a given style, genre, or role ⟨rejected the whole ~ about love-marriage-motherhood —Vance Packard⟩ — **a bit** : SOMEWHAT, RATHER ⟨the play was *a bit* dull⟩ — **a bit much** : a little more than one wants to endure — **bit by bit** : by degrees : LITTLE BY LITTLE

bit *n* [*binary digit*] (1948) 1 : a unit of computer information equivalent to the result of a choice between two alternatives (as *yes* or *no, on* or *off*) 2 : the physical representation of a bit by an electrical pulse, a magnetized spot, or a hole whose presence or absence indicates data

bi·tar·trate \(,)bī-'tär-,trāt\ *n* [ISV] (1879) : an acid tartrate

bitch \'bich\ *n* [ME *bicche*, fr. OE *bicce*] (bef. 12c) 1 : the female of the dog or some other carnivorous mammals 2 a : a lewd or immoral woman b : a malicious, spiteful, or domineering woman — sometimes used as a generalized term of abuse 3 : something that is highly objectionable or unpleasant 4 : COMPLAINT

bitch *vt* (1823) 1 : SPOIL, BOTCH ⟨I must have ~ed up my life —Mavis Gallant⟩ 2 : CHEAT, DOUBLECROSS ~ *vi* : to complain of or about ~ *vi* : COMPLAIN

bitch·ery \'bi-chə-rē\ *n, pl* **-er·ies** (1936) : malicious, spiteful, or domineering behavior; *also* : an instance of such behavior

bitch goddess *n* (1906) : SUCCESS; esp : material or worldly success

bitchy \'bi-chē\ *adj* **bitch·i·er; -est** (1937) : characterized by malicious, spiteful, or arrogant behavior — **bitch·i·ly** \'bi-chə-lē\ *adv* — **bitch·i·ness** \-chē-nəs\ *n*

bite \'bīt\ *vb* **bit** \'bit\; **bit·ten** \'bi-tᵊn\ *also* **bit; bit·ing** \'bī-tiŋ\ [ME, fr. OE *bītan*; akin to OHG *bīzan* to bite, L *findere* to split] *vt* (bef. 12c) 1 a : to seize esp. with teeth or jaws so as to enter, grip, or wound b : to wound, pierce, or sting esp. with a fang or a proboscis 2 a : to cut or pierce with or as if with an edged weapon 3 : to cause sharp pain or stinging discomfort to 4 : to take hold of 5 *archaic* : to take in : CHEAT ~ *vi* 1 : to bite or have the habit of biting something 2 *of a weapon or tool* : to cut, pierce, or take hold 3 : to cause irritation or smarting 4 : CORRODE 5 *of a fish* : to take a bait b : to respond so as to be caught (as by a trick) 6 : to take or maintain a firm hold — **bit·er** \'bī-tər\ *n* — **bite off more than one can chew** : to undertake more than one can perform — **bite the bullet** : to enter with resignation upon a difficult or distressing course of action — **bite the dust** 1 : to fall dead esp. in battle 2 : to suffer humiliation or defeat — **bite the hand that feeds one** : to injure a benefactor maliciously

bite *n* (15c) 1 : the act or manner of biting 2 : FOOD: as a : the amount of food taken at a bite.: MORSEL b : a small amount of food : SNACK 3 *archaic* a : CHEAT, TRICK b : SHARPER 4 : a wound made by biting 5 : the hold or grip by which friction is created or purchase is obtained 6 : a surface that creates friction or is brought into contact with another for the purpose of obtaining a hold 7 a : a keen incisive quality b : a sharp penetrating effect 8 : a single exposure of an etcher's plate to the corrosive action of acid 9 : an amount taken usu. in one operation for one purpose : CUT

bite·wing \'bīt-,wiŋ\ *n* (1938) : a dental X-ray film designed to show the crowns of the upper and lower teeth simultaneously

bit·ing \'bī-tiŋ\ *adj* (14c) : having the power to bite ⟨a ~ wind⟩; esp : able to grip and impress deeply ⟨the report is ~ in its intolerance of deceit⟩ — **bit·ing·ly** \-tiŋ-lē\ *adv*

\ə\ abut \ᵊ\ kitten, F table \ər\ further \a\ ash \ā\ ace \ä\ mop, mar
\au̇\ out \ch\ chin \e\ bet \ē\ easy \g\ go \i\ hit \ī\ ice \j\ job
\ŋ\ sing \ō\ go \ȯ\ law \ȯi\ boy \th\ thin \th̷\ the \ü\ loot \u̇\ foot
\y\ yet \zh\ vision \a, k, ᵒ, œ, œ̄, ᴜᴇ, ᴜᴇ̄, ᴜᴇ̄\ see Guide to Pronunciation

in·dign \in-'dīn\ adj [ME indigne, fr. MF, fr. L indignus] (14c) 1 archaic : UNWORTHY, UNDESERVING 2 obs : UNBECOMING, DISGRACEFUL

in·dig·nant \in-'dig-nənt\ adj [L indignant-, indignans, prp. of indignari to be indignant, fr. indignus unworthy, fr. in- + dignus worthy — more at DECENT] (1590) : filled with or marked by indignation (became ~ at the accusation) — **in·dig·nant·ly** adv

in·dig·na·tion \in-dig-'nā-shən\ n (14c) : anger aroused by something unjust, unworthy, or mean   syn see ANGER

in·dig·ni·ty \in-'dig-nə-tē\ n, pl -ties [L indignitat-, indignitas, fr. indignus] (1584) 1 a : an act that offends against a person's dignity or self-respect : INSULT b : humiliating treatment 2 obs : lack or loss of dignity or honor

in·di·go \'in-di-ˌgō\ n, pl -gos or -goes [It dial., fr. L indicum, fr. Gk indikon, fr. neut. of indikos Indic, fr. Indos India] (1555) 1 a : a blue vat dye obtained from plants (as indigo plants) b : the principal coloring matter $C_{16}H_{10}N_2O_2$ of natural indigo usu. synthesized as a blue powder with a coppery luster 2 : INDIGO PLANT 3 : a deep reddish blue

indigo bunting n (1783) : a common small American finch (Passerina cyanea) of which the male is largely indigo-blue in spring and summer

indigo plant n (1757) : a plant that yields indigo; esp : any of a genus (Indigofera) of leguminous herbs

indigo snake n (ca. 1885) : a large blue-black or brownish colubrid snake (Drymarchon corais) of the southeastern U.S. and Texas to Argentina — called also gopher snake

in·di·go·tin \in-'di-gə-tən, ˌin-di-'gō-tᵊn\ n [F indigotine, irreg. fr. indigo indigo] (1838) : INDIGO 1b

in·di·rect \ˌin-də-'rekt, -(ˌ)dī-\ adj [ME, fr. ML indirectus, fr. L in- + directus direct — more at DRESS] (14c) : not direct: as a (1) : deviating from a direct line or course : ROUNDABOUT (2) : not going straight to the point (an ~ accusation) (3) : being or involving proof of a proposition or theorem by demonstration that its negation leads to an absurdity or contradiction b : not straightforward and open : DECEITFUL c : not directly aimed at or achieved (~ consequences) d : stating what a real or supposed original speaker said with changes in wording that conform the statement grammatically to the sentence in which it is included (~ discourse) (~ question) e : not effected by the action of the people or the electorate (~ government representation) — **in·di·rect·ly** \-'rek(t)-lē\ adv — **in·di·rect·ness** \-nəs\ n

indirect cost n (ca. 1909) : a cost that is not identifiable with a specific product, function, or activity

indirect evidence n (1824) : evidence that establishes immediately collateral facts from which the main fact may be inferred : CIRCUMSTANTIAL EVIDENCE

in·di·rec·tion \ˌin-də-'rek-shən, -(ˌ)dī-\ n (1590) 1 a : indirect action or procedure b : lack of direction : AIMLESSNESS 2 a : lack of straightforwardness and openness : DECEITFULNESS b : something (as an act or statement) marked by lack of straightforwardness (hated diplomatic ~s —Rev. of Reviews)

indirect lighting n (1922) : lighting in which the light emitted by a source is diffusely reflected (as by the ceiling)

indirect object n (1879) : a grammatical object representing the secondary goal of the action of its verb (as her in "I gave her the book")

in·dis·cern·ible \ˌin-di-'sər-nə-bəl, -'zər-\ adj (1635) : incapable of being discerned : not recognizable as distinct

in·dis·ci·plin·able \(ˌ)in-'di-sə-'pli-nə-bəl; -'di-sə-plə-\ adj (1600) : not subject to or capable of being disciplined

in·dis·ci·pline \(ˌ)in-'di-sə-plən n (1783) : lack of discipline — **in·dis·ci·plined** \-plənd, -(ˌ)plīnd\ adj

in·dis·cov·er·able \ˌin-dis-'kəv-rə-bəl, -'kə-və-\ adj (1640) : not discoverable

in·dis·creet \ˌin-di-'skrēt\ adj [ME indiscrete, fr. MF & LL; MF indiscret, fr. LL indiscretus, fr. L, indistinguishable, fr. in- + discretus, pp. of discernere to separate — more at DISCERN] (15c) : not discreet : IMPRUDENT — **in·dis·creet·ly** adv — **in·dis·creet·ness** n

in·dis·cre·tion \ˌin-dis-'kre-shən\ n (14c) 1 : lack of discretion : IMPRUDENCE (dietary ~) 2 a : something (as an act or remark) marked by lack of discretion b : an act at variance with the accepted morality of a society (resigned because of financial ~s)

in·dis·crim·i·nate \ˌin-dis-'krim-nət, -'kri-mə-\ adj (ca. 1598) 1 a : not marked by careful distinction : deficient in discrimination and discernment (~ reading habits) (~ mass destruction) b : HAPHAZARD, RANDOM (~ application of a law) 2 a : PROMISCUOUS, UNRESTRAINED (~ sexual behavior) b : HETEROGENEOUS, MOTLEY (an ~ collection) — **in·dis·crim·i·nate·ly** adv — **in·dis·crim·i·nate·ness** n

in·dis·crim·i·nat·ing \-'kri-mə-ˌnā-tiŋ\ adj (ca. 1767) : not discriminating — **in·dis·crim·i·nat·ing·ly** \-tiŋ-lē\ adv

in·dis·crim·i·na·tion \ˌkri-mə-'nā-shən\ n (1649) : lack of discrimination

in·dis·pens·able \ˌin-di-'spen(t)-sə-bəl\ adj (1653) 1 : not subject to being set aside or neglected (an ~ obligation) 2 : absolutely necessary : ESSENTIAL (an ~ member of the staff) — **in·dis·pens·abil·i·ty** \-ˌspen(t)-sə-'bi-lə-tē\ n — **indispensable** n — **in·dis·pens·able·ness** \-'spen(t)-sə-bəl-nəs\ n — **in·dis·pens·ably** \-blē\ adv

in·dis·pose \ˌin-di-'spōz\ vt -posed; -pos·ing [prob. back-formation fr. indisposed] (1657) 1 a : to make unfit : DISQUALIFY b : to make averse : DISINCLINE 2 archaic : to cause to be in poor physical health

in·dis·posed \-'spōzd\ adj (15c) 1 : slightly ill 2 : AVERSE

in·dis·po·si·tion \(ˌ)in-ˌdis-pə-'zi-shən\ n (15c) : the condition of being indisposed: a : DISINCLINATION b : a usu. slight illness

in·dis·put·able \ˌin-di-'spyü-tə-bəl, (ˌ)in-'dis-pyə-\ adj [LL indisputabilis, fr. L in- + disputabilis disputable] (1551) : not disputable : UNQUESTIONABLE (~ proof) — **in·dis·put·able·ness** n — **in·dis·put·ably** \-blē\ adv

in·dis·so·cia·ble \ˌin-di-'sō-sh(ē-)ə-bəl, -sē-ə-\ adj (1855) : not dissociable : INSEPARABLE — **in·dis·so·cia·bly** \-blē\ adv

in·dis·sol·u·ble \ˌin-di-'säl-yə-bəl\ adj (1542) : not dissoluble; esp : incapable of being annulled, undone, or broken : PERMANENT (an ~ contract) — **in·dis·sol·u·bil·i·ty** \-ˌsäl-yə-'bi-lə-tē\ n — **in·dis·sol·u·ble·ness** \-'säl-yə-bəl-nəs\ n — **in·dis·sol·u·bly** \-blē\ adv

in·dis·tinct \ˌin-di-'stiŋ(k)t\ adj [L indistinctus, fr. in- + distinctus distinct] (1526) : not distinct: a : not sharply outlined or separable : BLURRED (~ figures in the fog) b : FAINT, DIM (an ~ light in the distance) c : not clearly recognizable or understandable : UNCERTAIN — **in·dis·tinct·ly** \-'stiŋ(k)t-lē, -'stiŋ-klē\ adv — **in·dis·tinct·ness** \-'stiŋ(k)t-nəs, -'stiŋk-nəs\ n

in·dis·tinc·tive \-'stiŋ(k)-tiv\ adj (1846) : lacking distinctive qualities

in·dis·tin·guish·able \ˌin-di-'stiŋ-gwi-shə-bəl, -'stiŋ-wi-\ adj (1606) : not distinguishable: as a : indeterminate in shape or structure b : not clearly recognizable or understandable c : lacking identifying or individualizing qualities — **in·dis·tin·guish·abil·i·ty** \-ˌstiŋ-gwi-shə-'bi-lə-tē, -ˌstiŋ-wi-\ n — **in·dis·tin·guish·able·ness** \-'stiŋ-gwi-shə-bəl-nəs, -'stiŋ-wi-\ n — **in·dis·tin·guish·ably** \-blē\ adv

in·dite \in-'dīt\ vt **in·dit·ed; in·dit·ing** [ME enditen, fr. OF enditer to write down, proclaim, fr. (assumed) VL indictare to proclaim, freq. of L indicere to proclaim, fr. in- + dicere to say — more at DICTION] (14c) 1 a : MAKE UP, COMPOSE (~ a poem) b : to give literary or formal expression to c : to put down in writing (~ a message) 2 obs : DICTATE — **in·dit·er** n

in·di·um \'in-dē-əm\ n [ISV ind- + NL -ium] (1864) : a malleable fusible silvery metallic element that is chiefly trivalent, occurs esp. in sphalerite ores, and is used as a plating for bearings, in alloys having a low melting point, and in the making of transistors — see ELEMENT table

indium antimonide n (1957) : a synthetic compound InSb of indium and antimony that is a semiconducting and photosensitive material and is used esp. in infrared photodetectors

in·di·vid·u·al \ˌin-də-'vij-wəl, -'vi-jə-wəl, -'vi-jəl\ adj [ML individualis, fr. L individuus indivisible, fr. in- + dividuus divided, fr. dividere to divide] (15c) 1 obs : INSEPARABLE 2 a : of, relating to, or distinctively associated with an individual (an ~ effort) b : being an individual or existing as an indivisible whole c : intended for one person (an ~ serving) 3 : existing as a distinct entity : SEPARATE 4 : having marked individuality (an ~ style)   syn see SPECIAL, CHARACTERISTIC — **in·di·vid·u·al·ly** adv

²**individual** n (1605) 1 a : a particular being or thing as distinguished from a class, species, or collection: as (1) : a single human being as contrasted with a social group or institution (a teacher who works with ~s) (2) : a single organism as distinguished from a group b : a particular person (are you the ~ I spoke with on the telephone?) 2 : an indivisible entity 3 : the reference of a name or variable of the lowest logical type in a calculus

in·di·vid·u·al·ise Brit var of INDIVIDUALIZE

in·di·vid·u·al·ism \ˌin-də-'vij-wə-ˌli-zəm, -'vi-jə-\ n (1827) 1 a (1) : a doctrine that the interests of the individual are or ought to be ethically paramount; also : conduct guided by such a doctrine (2) : the conception that all values, rights, and duties originate in individuals b : a theory maintaining the political and economic independence of the individual, and stressing individual initiative, action, and interests; also : conduct or practice guided by such a theory 2 a : INDIVIDUALITY b : an individual peculiarity : IDIOSYNCRASY

in·di·vid·u·al·ist \-list\ n (1840) 1 : one that pursues a markedly independent course in thought or action 2 : one that advocates or practices individualism — **individualist** or **in·di·vid·u·al·is·tic** \-ˌvij-wə-'lis-tik, -ˌvi-jə-wə-, -ˌvi-jə-'lis-\ adj — **in·di·vid·u·al·is·ti·cal·ly** \-'lis-ti-k(ə-)lē\ adv

in·di·vid·u·al·i·ty \-ˌvi-jə-'wa-lə-tē\ n, pl -ties (1614) 1 a : total character peculiar to and distinguishing an individual from others b : PERSONALITY 2 archaic : the quality or state of being indivisible 3 : separate or distinct existence 4 : INDIVIDUAL PERSON

in·di·vid·u·al·ize \-'vij-wə-ˌlīz, -'vi-jə-wə-, -'vi-jə-ˌlīz\ vt -ized; -iz·ing (1637) 1 : to make individual in character 2 : to treat or notice individually : PARTICULARIZE 3 : to adapt to the needs or special circumstances of an individual (~ teaching according to student ability) — **in·di·vid·u·al·i·za·tion** \-ˌvij-wə-lə-'zā-shən, -ˌvi-jə-wə-, -ˌvi-jə-lə-\ n

individual medley n (ca. 1949) : a swimming race in which each contestant swims each part of the course with a different stroke

individual retirement account n (1974) : IRA

in·di·vid·u·ate \ˌin-də-'vij-ə-ˌwāt\ vt -at·ed; -at·ing (1614) 1 : to give individuality to 2 : to form into a distinct entity

in·di·vid·u·a·tion \-ˌvi-jə-'wā-shən\ n (1628) 1 : the act or process of individuating: as a (1) : the development of the individual from the universal , (2) : the determination of the individual in the general b : the process by which individuals in society become differentiated from one another c : regional differentiation along a primary embryonic axis 2 : the state of being individuated; specif : INDIVIDUALITY

in·di·vis·i·ble \ˌin-də-'vi-zə-bəl\ adj [ME, fr. LL indivisibilis, fr. L in- + LL divisibilis divisible] (14c) : not divisible — **in·di·vis·i·bil·i·ty** \-ˌvi-zə-'bi-lə-tē\ n — **indivisible** n — **in·di·vis·i·bly** \-'vi-zə-blē\ adv

Indo- comb form [Gk, fr. Indos India] 1 : India or the East Indies (Indo-Pakistani) 2 : Indo-European (Indo-Hittite)

In·do-Ar·y·an \ˌin-dō-'ar-ē-ən, -'er-; -'ar-yən\ n (1881) 1 : a member of one of the peoples of the Indian subcontinent speaking an Indo-European language . 2 : one of the early Indo-European invaders of southern Asia 3 : a branch of the Indo-European language family that includes Hindi, Bengali, Punjabi, and other languages spoken primarily in India, Pakistan, Bangladesh, and Sri Lanka — see INDO-EUROPEAN LANGUAGES table — **Indo-Aryan** adj

In·do-Chi·nese \-chī-'nēz, -'nēs\ n (ca. 1934) 1 : a native or inhabitant of Indochina 2 : SINO-TIBETAN — **Indo-Chinese** adj

in·doc·ile \(ˌ)in-'dä-səl also -ˌsīl, esp Brit -'dō-ˌsīl\ adj [MF, fr. L indocilis, fr. in- + docilis docile] (1603) : unwilling or indisposed to be taught or disciplined : INTRACTABLE — **in·do·cil·i·ty** \ˌin-dä-'si-lə-tē, -dō-\ n

in·doc·tri·nate \in-'däk-trə-ˌnāt\ vt -nat·ed; -nat·ing [prob. fr. ME endoctrinen, fr. MF endoctriner, fr. OF, fr. en- + doctrine doctrine] (1626) 1 : to instruct esp. in fundamentals or rudiments : TEACH 2 : to imbue with a usu. partisan or sectarian opinion, point of view, or principle — **in·doc·tri·na·tion** \(ˌ)in-ˌdäk-trə-'nā-shən\ n — **in·doc·tri·na·tor** \in-'däk-trə-ˌnā-tər\ n

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): contrary to nature, reason, or common sense: ABSURD — **pre-ter-ous-ly** adv — **pre-pos-ter-ous-ness** n

pre-po-ten-cy \(,)prē-'pō-t'n(t)-sē\ n (1646) 1 : the quality or state of being prepotent : PREDOMINANCE 2 : unusual ability of an individual ... to transmit its characters to offspring because of homozygous or numerous dominant genes

pre-po-tent \-t'nt\ adj [ME, fr. L praepotent-, praepotens, fr. prae- + powerful — more at POTENT] (15c) 1 a : having exceptional ... authority, or influence b : exceeding others in power 2 : exhibiting genetic prepotency — **pre-po-tent-ly** adv

prep-py or **prep-pie** \'pre-pē\ n, pl **prep-pies** [!prep] (1967) 1 : a ... at or a graduate of a preparatory school 2 : a person deemed ... or behave like a preppy

preppy or **preppie** adj (1967) 1 : relating to, characteristic of, or ... a preppy 2 : relating to or being a style of dress characterized ... classic clothing and neat appearance — **prep-pi-ly** \'pre-pə-lē\ ... **prep-pi-ness** \'pre-pē-nəs\ n

pre-pran-di-al \(,)prē-'pran-dē-əl\ adj (1822) : of, relating to, or suit- ... for the time just before dinner (a ~ drink)

pre-preg \'prē-,preg, 'prē-,\ n [pre- + impregnated] (1954) : a reinforc- ... or molding material (as paper or glass cloth) already impregnated ... a synthetic resin

pre-print \'prē-,print, ,prē-'print\ n (1889) 1 : an issue of a technical ... often in preliminary form before its publication in a journal 2 ... something (as an advertisement) printed before the rest of the publi- ... in which it is to appear

preprint \(,)prē-'print\ vt (1926) : to print in advance for later use

pre-pro-cess \(,)prē-'prä-,ses, -'prō-, -səs\ vt (1942) : to do preliminary processing of (as data) — **pre-pro-ces-sor** \-,se-sər; -'s-sər, -,sôr\ n

pre-pro-fes-sion-al \,prē-prə-'fesh-nəl, -'fe-shə-n'l\ adj (1926) : of or ... to the period preceding specific study for or practice of a pro- ...

preschool n (1895) : PREPARATORY SCHOOL

pre-pu-ber-al \(,)prē-'pyü-b(ə-)rəl\ adj (ca. 1935) : PREPUBERTAL

pre-pu-ber-tal \-'bər-t'l\ adj (1859) : of or relating to prepuberty

pre-pu-ber-ty \-'bər-tē\ n (1922) : the period immediately preceding puberty

pre-pu-bes-cence \,prē-pyü-'be-s'n(t)s\ n (1916) : PREPUBERTY

pre-pu-bes-cent \-s'nt\ adj (1904) : PREPUBERTAL — **prepubescent** n

pre-puce \'prē-,pyüs\ n [ME, fr. MF, fr. L praeputium] (15c) : FORE- ... also : a similar fold investing the clitoris — **pre-pu-tial** \prē-'pyü-shəl\ adj

pre-quel \'prē-kwəl\ n [pre- + -quel (as in sequel)] (1972) : a literary or ... work whose story precedes that of an earlier work

Pre-Ra-pha-el-ite \(,)prē-'ra-fē-ə-,līt, -'rä-, -'rä-\ n (1850) 1 a : a ... of a brotherhood of artists formed in England in 1848 to re- ... the artistic principles and practices regarded as characteristic of ... art before Raphael b : an artist or writer influenced by this ... 2 : a modern artist dedicated to restoring early Renais- ... ideals or methods — **Pre-Raphaelite** adj — **Pre-Ra-pha-el-...** \-,lī-,tī-zəm\ n

pre-reg-is-tra-tion \,prē-,re-jə-'strā-shən\ n (1967) : a special registra- ... (as for returning students) prior to an official registration period — **pre-reg-is-ter** \(,)prē-'re-jə-stər\ vi

pre-req-ui-site \(,)prē-'re-kwə-zət\ n (1633) : something that is neces- ... to an end or to the carrying out of a function — **prerequisite** adj

pre-rog-a-tive \pri-'rä-gə-tiv\ n [ME, fr. MF & L; MF, fr. L prae- ... Roman century voting first in the comitia, privilege, fr. fem. of ... voting first, fr. praerogatus, pp. of praerogare to ask for an ... before another, fr. prae- + rogare to ask — more at RIGHT] (15c) 1 a : an exclusive or special right, power, or privilege: as (1) ... belonging to an office or an official body (2) : one belonging to a person, group, or class of individuals (3) : one possessed by a nation ... attribute of sovereignty b : the discretionary power inhering in ... British Crown 2 : a distinctive excellence — **pre-rog-a-tived** adj

pres-age \'pre-sij, also pri-'sāj\ n [ME, fr. L praesagium, fr. praesagus ... a foreboding, fr. prae- + sagus prophetic — more at SEEK] (14c) 1 : something that foreshadows or portends a future event : OMEN 2 ... intuition or feeling of what is going to happen in the future 3 ... : PROGNOSTICATION 4 : warning or indication of the future — **pre-sage-ful** \'pre-,sij-fəl\ adj

pre-sage \'pre-sij, pri-'sāj\ vb **pre-saged; pre-sag-ing** vt (1562) 1 ... give an omen or warning of : FORESHADOW 2 : FORETELL, PREDICT ... to make or utter a prediction — **pre-sag-er** n, obs

pre-sanc-ti-fied \(,)prē-'san(k)-ti-,fīd\ adj (1758) : consecrated at a previous service — used of eucharistic elements

pres-by-ope \'prez-bē-,ōp; 'pres-bē-, -pē-\ n [prob. fr. F, fr. Gk presbys ... man + ōps eye — more at EYE] (ca. 1857) : one affected with pres- ...

pres-by-o-pia \,prez-bē-'ō-pē-ə, ,pres-\ n [NL] (1793) : a visual condi- ... which becomes apparent esp. in middle age and in which loss of ... of the lens of the eye causes defective accommodation and ... to focus sharply for near vision — **pres-by-o-pic** \-'ō-pik, ...\ adj or n

pres-by-ter \'prez-bə-tər, 'pres-\ n [LL, elder, priest, fr. Gk presbyteros, ... of presbys old man, elder; akin to Gk pro before and Gk bai- ... to go — more at FOR, COME] (1597) 1 : a member of the govern- ... body of an early Christian church 2 : a member of the order of ... in churches having episcopal hierarchies that include bishops, ... and deacons 3 : ELDER 4b — **pres-byt-er-ate** \prez-'bi-tə-rət, ...\ n

pres-by-te-ri-al \,prez-bə-'tir-ē-əl, ,pres-\ adj (ca. 1600) : of or relating ... presbyters or a presbytery — **pres-by-te-ri-al-ly** \-ē-ə-lē\ adv

presbyterial n, often cap (1928) : an organization of Presbyterian ... women associated with a presbytery

Pres-by-te-ri-an \-ē-ən\ n (1640) : a member of a Presbyterian church

Presbyterian adj (1641) 1 often not cap : characterized by a graded ... of representative ecclesiastical bodies (as presbyteries) exercis- ... legislative and judicial powers 2 : of, relating to, or constituting a ... Protestant Christian church that is presbyterian in government and ... traditionally Calvinistic in doctrine — **Pres-by-te-ri-an-ism** \-ē-ə-,ni-zəm\ n

pres-by-tery \'prez-bə-,ter-ē, 'pres-, -bə-trē\ n, pl **-ter-ies** [ME & LL;

Right column:

ME presbytory part of church reserved for clergy, fr. LL presbyterium group of presbyters, part of church reserved for clergy, fr. Gk presbyter-ion group of presbyters, fr. presbyteros elder, priest] (15c) 1 : the part of a church reserved for the officiating clergy 2 : a ruling body in presbyterian churches consisting of the ministers and representative elders from congregations within a district 3 : the jurisdiction of a presbytery 4 : the house of a Roman Catholic parish priest

pre-school \'prē-,skül, (,)prē-'\ adj (1914) : of, relating to, or consti-tuting the period in a child's life from infancy to the age of five or six that ordinarily precedes attendance at elementary school

pre-school \'prē-,skül\ n (ca. 1925) : NURSERY SCHOOL, KINDERGARTEN

pre-school-er \-,skü-lər\ n (1946) 1 : a child not yet old enough for school 2 : a child attending a preschool

pre-science \'pre-sh(ē-)ən(t)s, 'prē-, -s(ē-)ən(t)s\ n [ME, fr. LL prae-scientia, fr. L praescient-, praesciens, prp. of praescire to know before-hand, fr. prae- + scire to know — more at SCIENCE] (14c) : foreknowl-edge of events: a : divine omniscience b : human anticipation of the course of events : FORESIGHT — **pre-scient** \-sh(ē-)ənt, -s(ē-)ənt\ adj — **pre-scient-ly** adv

pre-sci-en-tif-ic \,prē-,sī-ən-'ti-fik\ adj (1858) : of, relating to, or hav-ing the characteristics of a period before the rise of modern science or a state prior to the application of the scientific method

pre-scind \pri-'sind\ vb [L praescindere to cut off in front, fr. prae- + scindere to cut — more at SHED] vi (1650) : to withdraw one's attention ~ vt : to detach for purposes of thought

pre-score \(,)prē-'skör, -'skör\ vt (1937) : to record (as sound) in ad-vance for use when the corresponding scenes are photographed in mak-ing movies

pre-scribe \pri-'skrīb\ vb **pre-scribed; pre-scrib-ing** [ME, fr. L prae-scribere to write at the beginning, dictate, order, fr. prae- + scribere to write — more at SCRIBE] vi (15c) 1 : to lay down a rule : DICTATE 2 [ME, fr. ML praescribere, fr. L, to write at the beginning] : to claim a title to something by right of prescription 3 : to write or give medical prescriptions 4 : to become by prescription invalid or unenforceable ~ vt 1 a : to lay down as a guide, direction, or rule of action : OR-DAIN b : to specify with authority 2 : to designate or order the use of as a remedy — **pre-scrib-er** n

pre-script \'prē-,skript, pri-'\ adj [ME, fr. L praescriptus, pp.] (ca. 1540) : prescribed as a rule — **pre-script** \'prē-,skript\ n

pre-scrip-tion \pri-'skrip-shən\ n [partly fr. ME prescripcion establish-ment of a claim, fr. MF prescription, fr. LL praescription-, praescriptio, fr. L, act of writing at the beginning, order, limitation of subject mat-ter, fr. praescribere; partly fr. L praescription-, praescriptio order] (14c) 1 a : the establishment of a claim of title to something under common law usu. by use and enjoyment for a period fixed by statute b : the right or title acquired under common law by such possession 2 : the process of making claim to something by long use and enjoyment 3 : the action of laying down authoritative rules or directions 4 a : a written direction for a therapeutic or corrective agent; specif : one for the preparation and use of a medicine b : a prescribed medicine c : something like a doctor's prescription (~s for economic recovery) 5 a : ancient or long continued custom b : a claim founded upon an-cient custom or long continued use 6 : something prescribed as a rule

prescription drug n (1951) : a drug that can be obtained only by means of a physician's prescription

pre-scrip-tive \pri-'skrip-tiv\ adj (1748) 1 : serving to prescribe (~ rules of usage) 2 : acquired by, founded on, or determined by pre-scription or by long-standing custom — **pre-scrip-tive-ly** adv

pre-se-lect \,prē-sə-'lekt\ vt (ca. 1859) : to choose in advance usu. on the basis of a particular criterion — **pre-se-lec-tion** \-'lek-shən\ n

pre-sell \(,)prē-'sel\ vt -**sold** \-'sōld\; -**sell-ing** (1947) 1 : to precondi-tion (as a customer) for subsequent purchase or create advance demand for (as a product) esp. through marketing strategies 2 : to sell in ad-vance (raised money to publish the book by preselling film rights)

pres-ence \'pre-z'n(t)s\ n (14c) 1 : the fact or condition of being pres-ent 2 a : the part of space within one's immediate vicinity b : the neighborhood of one of superior esp. royal rank 3 archaic : COMPANY 2a 4 : one that is present: as a : the actual person or thing that is present b : something present of a visible or concrete nature 5 a : the bearing, carriage, or air of a person; esp : stately or distinguished bearing b : a quality of poise and effectiveness that enables a per-former to achieve a close relationship with his audience 6 : something (as a spirit) felt or believed to be present

presence of mind (1665) : self-control so maintained in an emergency or in an embarrassing situation that one can say or do the right thing

pres-ent \'pre-z'nt\ n [ME, fr. OF, fr. presenter] (13c) : something presented : GIFT

pre-sent \pri-'zent\ vb [ME, fr. OF presenter, fr. L praesentare, fr. prae-sent-, praesens, adj.] vt (14c) 1 a (1) : to bring or introduce into the presence of someone esp. of superior rank or status (2) : to introduce socially b : to bring (as a play) before the public 2 : to make a gift to 3 : to give or bestow formally 4 a : to lay (as a charge) before a court as an object of inquiry b : to bring a formal public charge, in-dictment, or presentment against 5 : to nominate to a benefice 6 a : to offer to view : SHOW b : to bring to one's attention (this ~s a problem) 7 : to act the part of : PERFORM 8 : to aim, point, or direct (as a weapon) so as to face something or in a particular direction ~ vi 1 : to present a weapon 2 : to become manifest 3 : to come forward as a patient 4 : to make a presentation syn see GIVE — **pre-sent-er** n

pres-ent \'pre-z'nt\ adj [ME, fr. OF, fr. L praesent-, praesens, fr. prp. of praeesse to be before one, fr. prae- pre- + esse to be — more at IS] (14c) 1 : now existing or in progress 2 a : being in view or at hand b : existing in something mentioned or under consideration 3 : con-stituting the one actually involved, at hand, or being considered 4 : of, relating to, or constituting a verb tense that is expressive of pres-

\ə\ abut \'\ kitten, F table \ər\ further \a\ ash \ā\ ace \ä\ mop, mar \au\ out \ch\ chin \e\ bet \ē\ easy \g\ go \i\ hit \ī\ ice \j\ job \ŋ\ sing \ō\ go \ô\ law \oi\ boy \th\ thin \th\ the \ü\ loot \u\ foot \y\ yet \zh\ vision \ä, k, ᵉ, œ, ᵫ, ᵾ, ᵯ, ᵊ\ see Guide to Pronunciation

Left column:

c : to announce the presence, arrival, or sighting of d : to ~known to the proper authorities (~ a fire) e : to make a charge ~conduct against ~ vi I a : to give an account : TELL b : to ~nt oneself c : to account for oneself (~ed sick on Friday) 2 : to ~issue. or submit a report 3 : to act in the capacity of a reporter ~r-table \ri-'pōr-tə-bəl, -'pór-\ adj (1858) 1 : worth reporting (~ ~) 2 : required by law to be reported (~ income) (~ diseases) ~rt-age \ri-'pōr-tij, -'pōr-; esp for 2 .re-por-'tāzh, .re-pór-\ n [F, fr. ~er to report] (ca. 1864) 1 a : the act or process of reporting ~ b : something (as news) that is reported 2 : writing intended ~ean account of observed or documented events

~rt-card n (1920) 1 : a report on a student that is periodically ~itted by a school to the student's parents or guardian 2 : an ~tion of performance

~rt-ed-ly \ri-'pōr-tad-lē, -'pór-\ adv (1901) : according to report ~rt-er \ri-'pōr-tar, -'pór-\ n (14c) : one that reports: as a : one ~ makes authorized statements of law decisions or legislative pro-~ings b : one who makes a shorthand record of a speech or pro-~ing c (1) : one employed by a newspaper, magazine, or television ~pany to gather and report news (2) : one who broadcasts news — ~or-to-ri-al \.re-pə(r)-'tōr-ē-əl, .rē-, -'tór-\ adj — re-por-to-ri-al-ly ~rē\ adv

~rt out vt (1907) : to return after consideration and often with ~tions to a legislative body for action (after much debate the com-~ice reported the bill out)

~rt stage n (ca. 1906) : the stage in the British legislative process ~eding the third reading and concerned esp. with amendments and ~ils.

~s-al \ri-'pō-zəl\ n (1605) obs : the act of reposing ~pose \ri-'pōz\ vb re-posed; re-pos-ing [ME, fr. MF reposer, fr. OF, ~LL repausare, fr. L re- + LL pausa pause] vt ~c) : to lay at rest ~ vi 1 a : to lie at rest b : to lie dead (repos-~in state) c : to remain still or concealed 2 : to take a rest 3 ~dic : RELY 4 : to rest for support : LIE

~ose n (1509) 1 a : a state of resting after exertion or strain; esp ~t in sleep b : eternal or heavenly rest (pray for the ~ of a soul) ~c : a place of rest : PEACE, TRANQUILLITY (the ~ of the bayous) ~a harmony in the arrangement of parts and colors that is restful to ~eye 3 a : lack of activity : QUIESCENCE b : cessation or absence ~activity, movement, or animation (the face in ~ is grave and ~oughtful) 4 : composure of manner : POISE

~pose vt re-posed; re-pos-ing [ME, to replace, fr. L reponere (perf. ~nc! reposuī)] (15c) 1 archaic : to put away or set down : DEPOSIT 2 ~'to place (as confidence or trust) in someone or something b : to ~ice for control, management, or use

~ose-ful \ri-'pōz-fəl\ adj (1852) : of a kind to induce ease and relax-~ion — re-pose-ful-ly \-fə-lē\ adv — re-pose-ful-ness n ~os-it vt re-pos-it-ed \-'pä-zə-təd, -'piz-təd\; re-pos-it-ing \-'pä-zə-~\ -'piz-tin\ [L repositus, pp. of reponere to replace, fr. re- + ponere to ~ce — more at POSITION] (ca. 1641) 1 \ri-'pä-zət\ : DEPOSIT, STORE 2 ~rē-\ : to put back in place : REPLACE

~po-si-tion \.rē-pə-'zi-shən, .re-\ n (1588) : the act of repositing : the ~ate of being reposited

~position \.rē-pə-'zi-shən\ vt (ca. 1859) 1 : to change the position ~said : to revise the marketing strategy of (a product or a company) so ~ to increase sales

~pos-i-to-ry \ri-'pä-zə-.tōr-ē, -.tór-\ n, pl -ries (15c) 1 : a place, ~oom, or container where something is deposited or stored : DEPOSI-~ARY 2 : a side altar in a Roman Catholic church where the conse-~rated Host is reserved from Maundy Thursday until Good Friday 3 ~ne that contains or stores something nonmaterial (considered the ~book a ~ of knowledge) 4 : a place or region richly supplied with a ~atural resource 5 : a person to whom something is confided or en-~usted

~pository adj (1950) of a drug : designed to act over a prolonged ~riod (~ penicillin)

~pos-sess \.rē-pə-'zes, also .-'ses\ vt (15c) 1 a : to regain possession ~b : to resume possession in default of the payment of install-~ents due 2 : to restore to possession — re-pos-ses-sion \-'ze-shən ~lso -'se-\ n — re-pos-ses-sor \-'ze-sər also -'se-\ n

~pous-sé \rə-pü-'sā, -'pü-\ adj [F, lit., pushed back] (1858) 1 ~haped or ornamented with patterns in relief made by hammering or ~sing on the reverse side — used esp. of metal 2 : formed in relief ~poussé n (1858) 1 : repoussé work 2 : repoussé decoration ~pow-er \(,)rē-pau̇(-ə)r\ vt (1954) : to provide again or anew with ~ower, esp : to provide (as a boat) with a new engine

~re war of REF

~re-hend \.re-pri-'hend\ vt [ME, fr. L reprehendere, lit., to hold ~ack, fr. re- + prehendere to grasp — more at GET] (14c) : to voice ~isapproval of : CENSURE syn see CRITICIZE ~re-hen-si-ble \.re-pri-'hen(t)-sə-bəl\ adj (14c) : worthy of or de-~erving reprehension : CULPABLE — rep-re-hen-si-bil-i-ty \-.hen(t)-sə-~bi-lə-tē\ n — rep-re-hen-si-ble-ness \-'hen(t)-sə-bəl-nəs\ n — rep-~re-hen-si-bly \-blē\ adv ~re-hen-sion \-'hen(t)-shən\ n [ME reprehensioun, fr. MF or L: MF ~reprehension, fr. L reprehension-, reprehensio, fr. reprehensus] (14c) ~ the act of reprehending : CENSURE ~re-hen-sive \-'hen(t)-siv\ adj (1589) : serving to reprehend : con-~ying reprehension or reproof ~re-sent \.re-pri-'zent\ vb [ME, fr. MF representer, fr. L repraesen-~tare, fr. re- + praesentare to present] vt (14c) 1 : to bring clearly be-~fore the mind : PRESENT (a book which ~s the character of early Amer. ~a) 2 : to serve as a sign or symbol of (the flag ~s our country) 3 ~: to portray or exhibit in art : DEPICT 4 : to serve as the counterpart ~or image of : TYPIFY (a movie hero who ~s the ideals of the culture) 5 ~: to produce on the stage b : to act the part or role of 6 a (1) ~: to take the place of in some respect (2) : to act in the place of or for ~sp. by legal right b : to serve esp. in a legislative body by delegated ~authority usu. resulting from election 7 : to describe as having a spec-~fied character or quality (~s himself as a friend) 8 a : to give one's ~impression and judgment of : state in a manner intended to affect ~action or judgment b : to point out in protest or remonstrance 9 ~: to serve as a specimen, example, or instance of 10 a : to form an ~image or representation of in the mind b (1) : to apprehend (an ob-

Right column:

ject) by means of an idea (2) : to recall in memory 11 : to corre-spond to in essence : CONSTITUTE ~ vi : to make representations against something : PROTEST — rep-re-sent-able \-'zen-tə-bəl\ adj — rep-re-sent-er n

re-pre-sent \.rē-pri-'zent\ vt (1564) : to present again or anew — re-pre-sen-ta-tion \.rē-.pre-.zen-'tā-shən, -zən-\ n

rep-re-sen-ta-tion \.re-pri-.zen-'tā-shən, -zən-\ n (15c) 1 : one that represents: as a : an artistic likeness or image b (1) : a statement or account made to influence opinion or action (2) : an incidental or collateral statement of fact on the faith of which a contract is entered into c (1) : a dramatic production or performance d (1) : a usu. formal statement made against something or to effect a change (2) : a usu. formal protest 2 : the act or action of representing : the state of being represented: as a : REPRESENTATIONALISM 2 b (1) : the action or fact of one person standing for another so as to have the rights and obliga-tions of the person represented (2) : the substitution of an individual or class in place of a person (as a child for a deceased parent) c : the action of representing or the fact of being represented esp. in a legisla-tive body 3 : the body of persons representing a constituency —'rep-re-sen-ta-tion-al \-shnəl, -shə-n'l\ adj — rep-re-sen-ta-tion-al-ly adv

rep-re-sen-ta-tion-al-ism \-shnə-.li-zəm, -shə-n'l-.i-\ n (1899) 1 : the doctrine that the immediate object of knowledge is an idea in the mind distinct from the external object which is the occasion of perception 2 : the theory or practice of realistic representation in art —'rep-re-sen-ta-tion-al-ist \-.list, -ist\ n

'rep-re-sen-ta-tive \.re-pri-'zen-tə-tiv\ adj (1532) 1 : serving to repre-sent 2 a : standing or acting for another esp. through delegated authority b : of, based on, or constituting a government in which the many are represented by persons chosen from among them usu. by election 3 : serving as a typical or characteristic example (a ~ movie-goer) 4 : of or relating to representation or representationalism — rep-re-sen-ta-tive-ly adv — rep-re-sen-ta-tive-ness n — rep-re-sen-ta-tiv-i-ty \-.zen-tə-'ti-və-tē\ n

'representative n (1647) 1 : a typical example of a group, class, or quality : SPECIMEN 2 : one that represents another or others: as a (1) : one that represents a constituency as a member of a legislative body (2) : a member of the house of representatives of the U.S. Con-gress or a state legislature b : one that represents another as agent, deputy, substitute, or delegate usu. being invested with the authority of the principal c : one that represents a business organization : one that represents another as successor or heir

re-press \ri-'pres\ vb [ME, fr. L repressus, pp. of reprimere to check, fr. re- + premere to press — more at PRESS] vt (14c) 1 a : to check by or as if by pressure : CURB (injustice was ~ed) b : to put down by force : SUBDUE (~ a disturbance) 2 a : to hold in by self-control (~ed a laugh) b : to prevent the natural or normal expression, activity, or development of (~ed her anger) 3 : to exclude from consciousness 4 : to inactivate (a gene or formation of a gene product) by allosteric combination at a DNA binding site ~ vi : to take repressive action — re-press-ibil-i-ty \-'pre-sə-'bi-lə-tē\ n — re-press-ible \-'pre-sə-bəl\ adj — re-press-ive \-'pre-siv\ adj — re-press-ive-ly adv — re-press-ive-ness n

re-press \(.)rē-'pres\ vt (14c) : to press again (~ a record)

re-pressed \ri-'prest\ adj (1665) 1 : subjected to or marked by repres-sion 2 : characterized by restraint

re-pres-sion \ri-'pre-shən\ n (1533) 1 a : the action or process of repressing : the state of being repressed (~ of unpopular opinions) b : an instance of repressing (racial ~s) 2 a : a process by which un-acceptable desires or impulses are excluded from consciousness and left to operate in the unconscious b : an item so excluded — re-pres-sion-ist \-'sh(ə-)nist\ adj

re-pres-sor \ri-'pre-sər\ n [NL] (1611) : one that represses; esp : a protein that is determined by a regulatory gene, binds to a genetic op-erator, and inhibits the initiation of transcription of messenger RNA

re-priev-al \ri-'prē-vəl\ n (ca. 1586) archaic : REPRIEVE

're-prieve \ri-'prēv\ vt re-prieved; re-priev-ing [alter. of earlier repry, perh. fr. MF repris, pp. of reprendre to take back] (1596) 1 : to delay the punishment of (as a condemned prisoner) 2 : to give relief or de-liverance to for a time

'reprieve n (1592) 1 a : the act of reprieving : the state of being reprieved b : a formal temporary suspension of the execution of a sentence esp. of death 2 : an order or warrant for a reprieve 3 : a temporary respite (as from pain or trouble)

'rep-ri-mand \'re-prə-.mand\ n [F réprimande, fr. L reprimenda, fem. of reprimendus, gerundive of reprimere to check — more at REPRESS] (1636) : a severe or formal reproof

'reprimand vt (1681) : to reprove sharply or censure formally usu. from a position of authority syn see REPROVE

're-print \(.)rē-'print\ vt (1551) : to print again : make a reprint of

're-print \'rē-.print, (.)rē-'\ n (1611) : a reproduction of printed matter: as a : a subsequent printing of a book already published that pre-serves the identical text of the previous printing b : OFFPRINT c : matter (as an article) that has appeared in print before

re-print-er \(.)rē-'prin-tər\ n (1689) : one that publishes a reprint

re-pri-sal \ri-'prī-zəl\ n [ME reprisail, fr. MF reprisaille, fr. OIt ri-presaglia, fr. ripresa, pp. of riprendere to take back, fr. ri- re- (fr. L re-) + prendere to take, fr. L prehendere — more at GET] (15c) 1 a : the act or practice in international law of resorting to force short of war in retaliation for damage or loss suffered b : an instance of such action 2 obs : PRIZE 3 : the regaining of something (as by recapture) 4 : something (as a sum of money) given or paid in restitution — usu. used in pl. 5 : a retaliatory act

're-prise \ri-'prēz, 1 is also -'priz\ n [ME, fr. MF, lit., action of taking back, fr. OF, fr. reprendre to take back, fr. re- + prendre to take, fr. L prehendere] (15c) 1 : a deduction or charge made yearly out of a manor or estate — usu. used in pl. 2 : a recurrence, renewal, or re-

\ə\ abut \ᵊ\ kitten, F table \ər\ further \a\ ash \ā\ ace \ä\ mop, mar \au̇\ out \ch\ chin \e\ bet \ē\ easy \g\ go \i\ hit \ī\ ice \j\ job \ŋ\ sing \ō\ go \ȯ\ law \ȯi\ boy \th\ thin \th\ the \ü\ loot \u̇\ foot \y\ yet \zh\ vision \ä, k̟, ᵊ, œ, ᴔ, ᴕ, ᵫ, ᴝ\ see Guide to Pronunciation

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to David B. Guralnik
lexicographical mentor
and friend*

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protoactinium / provender   **1082**

pro·to·ac·tin·i·um (prōt'ō ak'tin'ē əm) *n.* early name for PROTACTINIUM

pro·to·col (prōt'ō kôl', -käl'; prōt'ō-; -kōl') *n.* [Early ModE *prothocoll* < MFr *prothocole* < ML *protocollum* < LGr *prōtokollon*, first leaf glued to a manuscript (describing the contents) < Gr *prōto-*, PROTO- + *kolla*, glue] 1 an original draft or record of a document, negotiation, etc. 2 [Fr *protocole*] a) a diplomatic agreement, esp. one that amends, clarifies, or adds to a treaty- b) the code of ceremonial forms and courtesies, of precedence, etc. accepted as proper and correct in official dealings, as between heads of states or diplomatic officials 3 a set of rules governing the communication and the transfer of data between machines, as in a computer system —*vt.* -colled' or -coled', -colling or -coling to issue in a protocol —*vi.* to draw up a protocol

Pro·to-Ger·man·ic (prōt'ō jər man'ik) *n.* the hypothetical prehistoric language from which all the Germanic languages, including English, are thought to be descended

pro·to·his·to·ry (prōt'ō his'tə rē) *n.* archaeological history in the period immediately preceding recorded history

pro·to·hu·man (-hyōō'mən) *adj.* of or relating to the humanlike primates that exist or did exist

pro·to·lith·ic (prōt'ō lith'ik, prōt'ə-) *adj.* [PROTO- + -LITHIC] early name for EOLITHIC

pro·to·mar·tyr (prōt'ō, mär'tər) *n.* [ME *prothomartir* < MFr < ML(Ec) *protomartyr* < LGr(Ec) *prōtomartyr*: see PROTO- & MARTYR] the first martyr (in some cause)

pro·ton (prō'tän) *n.* [ModL < Gr *proton*, neut. of *protos*, first: see PROTO-] an elementary particle found in the nucleus of all atoms and comprising the atomic nucleus of the protium isotope of hydrogen: it carries a unit positive charge equal to the negative charge of an electron and has a mass of 1.673×10^{24} gram, approximately 1836 times that of an electron: the atomic number of an atom is equal to the number of protons in its nucleus: see also NEUTRON

pro·to·ne·ma (prōt'ō nē'mə, prōt'ə-) *n., pl.* -ma·ta (-mə tə) [ModL < Gr *prōto-*, PROTO- + *nēma* (gen. *nēmatos*), thread] *Bot.* a threadlike growth in mosses; arising from a spore and developing small buds that grow into leafy moss plants —**pro·to·ne'mal** *adj.*

pro·to·nephrid·i·um (prōt'ō nə frid'ē əm; -ni-, -ne-; prōt'ə-) *n.* [PROTO- + NEPHRIDIUM] *Zool.* a tubular, excretory structure in certain invertebrates, as flatworms, rotifers, and some larvae, usually ending internally in flame cells and having an external pore

pro·to·no·ta·ry (prō tän'ə terē; *also* prōt'ə nōt'ər ē) *n., pl.* -ries PROTHONOTARY

☆**proton synchrotron** a synchrotron for accelerating protons and other heavy particles to very high energies

pro·to·nymph (prōt'ō nimf, prōt'ə-) *n.* [PROTO- + NYMPH] the newly hatched form of various mites —**pro·to·nymph'al** *adj.*

pro·to·path·ic (prōt'ō path'ik, prōt'ə-) *adj.* [PROTO- + -PATHIC] *Physiol.* designating or of certain sensory nerves having limited sensibility, that respond to heat and pain from a general area

pro·to·plasm (prōt'ō plaz'əm, prōt'ə-) *n.* [Ger *protoplasma*: see PROTO- & PLASMA] a semifluid, viscous, translucent colloid, the essential living matter of all animal and plant cells: it consists largely of water, proteins, lipids, carbohydrates, and inorganic salts and is differentiated into nucleoplasm and cytoplasm —**pro·to·plas'mic** (-plaz'mik) *adj.*

pro·to·plast (prōt'ō plast', prōt'ə-) *n.* [Fr *protoplaste* < LL *protoplastus* < Gr *protoplastos*, formed first < *protos*, first (see PROTO-) + *plastos*, formed < *plassein*, to form: see PLASTIC] 1 a thing or being that is the first of its kind 2 *Biol.* ENEROID 3 *Bot.* a unit of protoplasm, such as makes up a single cell exclusive of the cell wall —**pro'to·plas'tic** *adj.*

pro·to·stele (prōt'ō stēl', -stē'lē, prōt'ə-) *n.* [PROTO- + STELE] a simple, primitive arrangement of conducting tissues in stems and roots of certain lower plants, consisting of a solid cylinder of xylem surrounded by a layer of phloem —**pro'to·ste'lic** *adj.*

pro·to·trophic (prōt'ō träf'ik) *adj.* [PROTO- + -TROPHIC] able to synthesize its required growth factors: said as of an original organism from which auxotrophic mutants are derived

pro·to·type (prōt'ō tīp', prōt'ə-) *n.* [Fr < Gr *prōtotypon* < *prōtotypos*, original: see PROTO- & TYPE] 1 the first thing or being of its kind; original; model; pattern; archetype 2 a person or thing that serves as a model for one of a later period 3 a perfect example of a particular type —**pro'to·typ'al** (-tī'pəl), **pro'to·typ'ic** (-tip'ik), or **pro'to·typ'i·cal** *adj.*

pro·tox·ide (prō täks'īd') *n.* [PROT(O)- + OXIDE] that one of any series of oxides that contains the smallest proportion of oxygen

pro·to·xy·lem (prōt'ō zī'ləm, -lem'; prōt'ə-) *n. Bot.* the first formed xylem of a root or stem, produced by the differentiation of the procambium

pro·to·zo·an (prōt'ō zō'ən, prōt'ə-) *n.* [< ModL *Protozoa*, name of the phylum (see PROTO- & -ZOA) + -AN] *pl.* -zo'a (-ə) any of a subkingdom (Protozoa) of microscopic animals made up of a single cell or a group of more or less identical cells and living in water or as parasites, including ciliates, flagellates, rhizopods, and sporozoans. Also **pro'to·zo'on** (-än'), *pl.* -zo'a (-ə) —*adj.* of the protozoans. Also **pro·to·zo'ic** (-ik)

pro·to·zo·ol·o·gy (prōt'ō zō äl'ə jē, prōt'ə-) *n.* that branch of zoology dealing with the study of the protozoans

pro·tract (prō trakt', prə-) *vt.* [< L *protractus*, pp. of *protrahere* < *pro-*, forward + *trahere*, to DRAW] 1 to draw out; lengthen in duration; prolong 2 to draw to scale; using a protractor and scale 3 *Zool.* to thrust out; extend: opposed to RETRACT —*SYN.* EXTEND —**pro·tract'ed·ly** *adv.* —**pro·tract'ed·ness** *n.* —**pro·tract'i·ble** *adj.* —**pro·trac'tion** *n.* —**pro·trac'tive** *adj.*

pro·trac·tile (prō trak'təl) *adj.* capable of being protracted or thrust out; extensible

pro·trac·tor (prō'trak'tər, prō trak'-) *n.* [ML] 1 a person or thing that protracts 2 an instrument in the form of a graduated semicircle, used for plotting and measuring angles 3 *Anat.* a muscle that protracts, or extends, a limb

PROTRACTOR
DAC, angle measured

pro·trep·tic (prō trep'tik) *adj.* intended as instructional; didactic —*n.* a book, speech, etc. that is protreptic

pro·trude (prō trōōd', prə-) *vt., vi.* -trud'ed, -trud'ing [L *protrudere* < *pro-*, forth + *trudere*, to THRUST] to thrust or jut out; project —**pro·trud'ent** *adj.*

pro·tru·sile (prō trōō'səl, -zəl) *adj.* [< L *protrusus*, pp. of *protrudere* (see prec.) + -ILE] that can be protruded, or thrust out, as a tentacle or an elephant's trunk. Also **pro·tru'si·ble** (-sə bəl, -zə-)

pro·tru·sion (prō trōō'zhən, prə-) *n.* [< L *protrusus* (see prec.) + -ION] 1 a protruding or being protruded 2 a protruding part or thing —*SYN.* PROJECTION

pro·tru·sive (prō trōō'siv, prə-) *adj.* [< L *protrusus* (see PROTRUSILE) + -IVE] 1 protruding; jutting or bulging out 2 OBTRUSIVE —**pro·tru'sively** *adv.* —**pro·tru'sive·ness** *n.*

pro·tu·ber·ance (prō tōō'bər əns, -tyōō'-; prə-) *n.* 1 the condition of fact of being protuberant 2 a part or thing that protrudes; projection; bulge; swelling. Also **pro·tu'ber·an·cy** (-ən sē), *pl.* -cies —*SYN.* PROJECTION

pro·tu·ber·ant (prō tōō'bər ənt, -tyōō'-; prə-) *adj.* [LL *protuberans*, prp. of *protuberare*, to bulge out < L *pro-*, forth + *tuber*, bump, bulge: see TUBER] bulging or swelling out; protruding; prominent —**pro·tu'ber·ant·ly** *adv.*

pro·tu·ber·ate (-āt') *vi.* -at·ed, -at·ing [< LL *protuberatus*, pp. of *protuberare*: see prec.] to bulge or swell out

proud (proud) *adj.* [ME < OE *prud* < OFr < LL *prode*, beneficial, back-form. < L *prodesse*, to be useful < *prod-*, var. of *pro-*, PRO- + *esse*, to be: for IE base see IS] 1 having or showing a proper pride in oneself, one's position, one's family, etc. 2 having or showing an overweening opinion of oneself, one's position, etc.; arrogant; haughty 3 feeling or showing great pride or joy, as from being honored 4 that is an occasion or cause of pride; highly gratifying 5 arising from or caused by pride; presumptuous 6 stately; splendid [a proud fleet] 7 spirited; of high mettle [a proud stallion] 8 [Obs.] valiant —do oneself proud [Colloq.] to do extremely well —**proud** of highly pleased with or exulting in —**proud'ly** *adv.*

SYN.—**proud** is the broadest term in this comparison, ranging in implication from proper self-esteem or pride to an overweening opinion of one's importance [too proud to beg; proud as a peacock]; **arrogant** implies an aggressive, unwarranted assertion of superior importance or privileges [the arrogant colonel]; **haughty** implies such consciousness of high station, rank, etc. as is displayed in scorn of those one considers beneath one [a haughty dowager]; **insolent**, in this connection, implies both haughtiness and great contempt, esp. as manifested in behavior or speech that insults or affronts others [she has an insolent disregard for her servant's feelings]; **overbearing** implies extreme, domineering insolence [an overbearing supervisor]; **supercilious** stresses an aloof, scornful manner toward others [a supercilious intellectual snob]; **disdainful** implies even stronger and more overt feelings of scorn for that which is regarded as beneath one. —*ANT.* humble

proud flesh [so called from the notion of swelling up] an abnormal growth of flesh around a healing wound, caused by excessive granulation

Prou·dhon (prōō dōn'), **Pierre Jo·seph** (pyer zhō zef') 1809-65; Fr. socialist & writer

Proust (prōōst), **Mar·cel** (mär sel') 1871-1922; Fr. novelist —**Proust'i·an** *adj.*

prov 1 province 2 provincial 3 provisional

Prov 1 Provencal 2 *Bible* Proverbs 3 Province 4 Provost

prove (prōōv) *vt.* proved, proved or prov'en, prov'ing [ME *proven* < OFr *prover* < L *probare*: see PROBE] 1 to test by experiment, a standard, etc.; subject to a testing process; try out 2 to establish as true; demonstrate to be a fact 3 to establish the validity or authenticity of (esp. a will) 4 to show (oneself) to be capable, dependable, etc. 5 [Archaic] to experience; learn or know by experience 6 *Math.* to test or verify the correctness of (a calculation, etc.) 7 *Printing* to take a proof of (type, etc.) —*vi.* 1 to be found or shown by experience or trial; turn out to be [a guess that proved right] 2 [Archaic] to make trial —**the exception proves the rule** see EXCEPTION —**prove out** to show or be shown to be satisfactory, accurate, true, etc. —**prov·abil'i·ty** or **prov'able·ness** *n.* —**prov'able** *adj.* —**prov'ably** *adv.* —**prov'er** *n.*

prov·en (prōōv'ən) *vt., vi. pp.* of PROVE —*adj.* known to be valid, effective, or genuine [a proven method]

prov·e·nance (präv'ə nəns) *n.* [Fr < *provenir* < L *provenire*, to come forth < *pro-*, forth + *venire*, to COME] origin; derivation; source

Pro·ven·çal (prō'vän säl', -vən-; präv'ən-; Fr prō vän säl') *adj.* [Fr] of Provence, its people, their language, etc. —*n.* 1 the vernacular of S. France; a Romance language comprising several dialects 2 the medieval language of S. France, a literary language as cultivated by the troubadours 3 a native or inhabitant of Provence

Pro·vence (prō väns') [Fr < L *provincia*, PROVINCE] historical region of SE France, on the Mediterranean

Pro·vence-Côte d'Azur (kōt' dä zür') metropolitan region of SE France; 12,137 sq. mi. (31,435 sq. km); pop. 3,965,000; chief city, Marseille

prov·en·der (präv'ən dər) *n.* [ME < MFr *provendre*, var. of *provende*
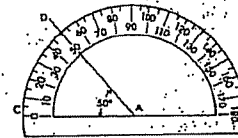
nāt) *adj.* [ME < ML *subordinatus,* pp. of *subordinare* < L *sub-,* under + *ordinare,* to order: see ORDAIN] 1 inferior to or placed below another in rank, power, importance, etc.; secondary 2 under the power or authority of another 3 subservient or submissive 4 *Gram.* having the function of a noun, adjective, or adverb within a sentence [a *subordinate phrase*] —*n.* a subordinate person or thing —*vt.* -nat'ed, -nat'ing 1 to place in a subordinate position; treat as less important or inferior (*to*) 2 to make obedient or subservient (*to*); control; subdue —**sub·or'di·nate·ly** *adv.* —**sub·or'di·na'tive** (-'n āt'iv) *adj.*

subordinate clause *Gram.* DEPENDENT CLAUSE

subordinating conjunction a conjunction that connects subordinate words, phrases, or clauses to some other sentence element (Ex.: *if, as, so, unless, although, when*). Also **subordinate conjunction**

sub·or·di·na·tion (sə bôrd''n ā'shən, -bôr'də nā'-) *n.* 1 a subordinating or being subordinated 2 [Now Rare] subjection or submission to rank, power, or authority; obedience

sub·orn (sə bôrn') *vt.* [L *subornare,* to furnish or supply, instigate, incite secretly < *sub-,* under + *ornare,* to furnish, adorn: see ORNAMENT] 1 to get or bring about through bribery or other illegal methods 2 to induce or instigate (another) to do something illegal, esp. to commit perjury —**sub·orn'er** *n.*

sub·or·na·tion (sub'ôr nā'shən) *n.* [ML *subornatio*] a suborning or being suborned; esp., the crime of inducing another to commit perjury (*subornation of perjury*)

sub·ox·ide (sub äks'īd') *n.* an oxide containing a relatively small proportion of oxygen

sub·phy·lum (sub'fī'ləm) *n., pl.* -la (-lə) any main natural subdivision of a phylum

sub·plot (-plät') *n.* a secondary plot in a play, novel, etc.

sub·poe·na (sə pē'nə) *n.* [ME *suppena* < ML *subpena* < L *sub poena,* lit., under penalty: see SUB- & PAIN] a written legal order directing a person to appear in court to give testimony, show specified records, etc. —*vt.* -naed, -na·ing 1 to summon with such an order 2 to order that (specified records, documents, etc.) be brought to a court. Also sp. **sub·pe'na**

sub·pop·u·la·tion (sub'päp' yoo lā'shən, -yə-) *n.* a subdivision of a population, with common, distinguishing characteristics

sub·prin·ci·pal (sub'prin'sə pəl) *n.* 1 an assistant principal in a school, etc. 2 a secondary brace or rafter

☆**sub·pro·fes·sion·al** (sub'prə fesh'ə nəl) *n.* PARAPROFESSIONAL

sub·re·gion (sub're·jən) *n.* any of the divisions of a region, esp. with reference to plant and animal distribution

sub·rep·tion (sub rep'shən) *n.* [L *subreptio < subreptus,* pp. of *subripere, surripere,* to take away secretly: see SURREPTITIOUS] 1 deliberate concealment or misrepresentation of facts so as to gain some benefit or advantage 2 an erroneous inference or conclusion induced by this —**sub·rep·ti·tious** (sub'rep ti'shəs) *adj.*

sub·ro·gate (sub'rə gāt') *vt.* -gat'ed, -gat'ing [< L *subrogatus, surrogatus:* see SURROGATE] to substitute (one person) for another

sub·ro·ga·tion (sub'rō gā'shən, -rə-) *n.* [ME *subrogacioun* < ML *subrogatio* < L *subrogatus*] a subrogating; esp., the substitution of one creditor for another, along with a transference of the claims and rights of the old creditor

sub ro·sa (sub rō'zə) [L, lit., under the rose, an ancient symbol of secrecy] secretly; privately; confidentially

sub·rou·tine (sub'rōō tēn') *n.* a set of instructions, appearing once within a computer program but available for repeated use, for performing a specific task

sub-Sa·ha·ran (sub'sə har'ən) *adj.* designating or of the part of the African continent south of the Sahara desert

sub·sam·ple (sub'sam'pəl) *n.* a selected sample of a total sampling —*vt.* -sam·pled, -sam·pling to take a subsample of

sub·scribe (səb skrīb') *vt.* -scribed', -scrib'ing [ME *subscriben* < L *subscribere:* see SUB- & SCRIBE] 1 to sign (one's name) at the end of a document, etc. 2 to write one's signature on (a document, etc.) as an indication of consent, approval, attestation, etc. 3 to support; consent to; favor; sanction. 4 to promise to contribute (a sum of money), esp. by signing a pledge —*vi.* 1 to sign one's name at the end of a document, etc. 2 to give support, sanction, or approval; consent or agree (*to*) (*to subscribe to certain measures*) 3 to promise to contribute, or to give, a sum of money 4 to agree to receive and pay for a periodical, service, theater tickets, etc. for a specified period of time (with *to*) —**sub·scrib'er** *n.*

sub·script (sub'skript) *adj.* [L *subscriptus,* pp. of *subscribere,* to SUBSCRIBE] written below; esp., INFERIOR (*adj.* 8) —*n.* a figure, letter, or symbol written below and to the side of another [in Y₂ and X₂, 2 and *a* are *subscripts*]

sub·scrip·tion (səb skrip'shən) *n.* [ME *subscription* < L *subscriptio*] 1 the act of subscribing 2 something subscribed: specif., *a*) a written signature *b*) a signed document, etc. *c*) consent or sanction, esp. in writing, *d*) an amount of money subscribed *e*) a formal agreement to receive and pay for a periodical, books, theater tickets, etc. for a specified period of time *f*) the right to receive a periodical, etc., as by payment of a fixed sum 3 that part of a doctor's prescription giving directions to the pharmacist .cf. SIGNATURE (*n.* 4) 4 *Eccles.* assent to certain doctrines for promoting uniformity; specif., in the Anglican Church, acceptance of the Thirty-nine Articles of Faith

sub·sec·tion (sub'sek'shən) *n.* a subdivision of any of the sections into which a group, document, etc. is divided

sub·se·quence (sub'si kwəns, -kwens') *n.* [ME *subsequentia*] 1 the fact or condition of being subsequent 2 a subsequent happening 3 *Math.* a sequence within a sequence

sub·se·quent (-kwant, -kwent') *adj.* [ME < L *subsequens,* prp. of *subsequi,* to follow close after: see SUB- & SEQUENT] coming after;

1335   subordinately / substandard

following in time, place, or order —**subsequent to** after; following —**sub'se·quent·ly** *adv.*

sub·sere (sub'sir') [SUB- + SERE¹] *Ecol.* a secondary succession occurring after all or part of the vegetation in an area has been destroyed, as by humans or fire

sub·serve (səb surv') *vt.* -served', -serv'ing [L *subservire < sub-,* under + *servire,* to SERVE] to be useful or helpful to (a purpose, cause, etc.); serve; promote; aid

sub·ser·vi·ence (-sur'vē əns) *n.* 1 the state or quality of being subservient 2 subservient behavior or manner; obsequiousness; servility Also **sub·ser'vi·en·cy**

sub·ser·vi·ent (-ənt) *adj.* [L *subserviens,* prp. of *subservire,* to SUBSERVE] 1 that is useful, helpful, or of service, esp. in an inferior or subordinate capacity 2 submissive; obsequious —**sub·ser'vi·ent·ly** *adv.*

sub·set (sub'set') *n.* a mathematical set containing some or all of the elements of a given set

sub·shrub (-shrub') *n.* a partly shrubby plant that has woody stems growing new shoots annually at the tips

sub·side (səb sīd') *vi.* -sid'ed, -sid'ing [L *subsidere < sub-,* under + *sidere,* to settle < *sedere,* to SIT] 1 to sink or fall to the bottom; settle, as sediment 2 to sink to a lower level 3 to become less active, intense, etc.; abate —SYN. WANE —**sub·sid'ence** (-sīd''ns, sub'si dəns) *n.*

sub·sid·i·ar·y (səb sid'ē er'ē, -ə rē) *adj.* [L *subsidiarius < subsidium:* see SUBSIDY] 1 giving aid, support, service, etc.; serving to supplement; auxiliary 2 being in a secondary or subordinate relationship 3 of, constituting, or maintained by a subsidy or subsidies —*n., pl.* -ar·ies a person or thing that is subsidiary; specif., *a*) a company controlled by another company which owns all or a majority of its shares (in full **subsidiary company**) *b*) *Music* a subordinate theme —**sub·sid'i·ar'i·ly** *adv.*

sub·si·dize (sub'sə dīz') *vt.* -dized', -diz'ing [< fol. + -IZE] 1 to support with a subsidy 2 to buy the aid or support of with a subsidy, often as a kind of bribe —**sub·si·di·za'tion** *n.* —**sub'si·diz'er** *n.*

sub·si·dy (sub'sə dē) *n., pl.* -dies [ME < Anglo-Fr *subsidie* < L *subsidium,* auxiliary forces; reserve troops, aid, support < *subsidere,* to sit down, remain: see SUBSIDE] a grant of money; specif., *a*) a grant of money from one government to another, as for military aid *b*) a government grant to a private enterprise considered of benefit to the public *c*) [Historical] in England, money granted by Parliament to the king

sub·sist (səb sist') *vi.* [L *subsistere,* to stand still, stay, abide < *sub-,* under + *sistere,* to place, stand, redupl. of base of *stare,* to STAND] 1 *a*) to continue to be or exist; have existence as a reality, entity, etc. *b*) to continue to be in use, force, etc. 2 to continue to live; remain alive (on *sustenance, by specific means,* etc.); be sustained 3 to consist or inhere (*in*) 4 *Philos.* to be logically conceivable and have being as a conceptual entity that may be the subject of true statements —*vt.* to maintain with sustenance; support

sub·sist·ence (-sis'təns) *n.* [ME < LL(Ec) *subsistentia* < L *subsister:* see prec.] 1 existence; being; continuance 2 the act of providing sustenance 3 means of support or livelihood; often, specif., the barest means in terms of food, clothing, and shelter needed to sustain life 4 the quality of being inherent 5 *Philos. a*) the status of something that exists in itself as an individual whole *b*) the status of something whose very act of existing is its essence, as God *c*) the quality of being logically conceivable —**sub·sist'ent** *adj.*

sub·soil (sub'soil') *n.* the layer of soil beneath the topsoil —*vt.* to stir or turn up the subsoil of —**sub'soil'er** *n.*

sub·so·lar (sub sō'lər) *adj.* [SUB- + SOLAR] 1 located under the sun 2 having the sun in the zenith

sub·son·ic (-sän'ik) *adj.* [SUB- + SONIC] 1 designating, of, or moving at a speed in a surrounding fluid less than that of sound in the same fluid 2 INFRASONIC

sub·space (sub'spās') *n. Math.* a space which forms a proper subset of some larger space

sub specie ae·ter·ni·ta·tis (sub spā'shi ē', ē tur'ni tā'tis) [L, lit., under the aspect of eternity] from the standpoint of eternity

sub·spe·cies (sub'spē'shēz) *n.* [ModL: see SUB- + SPECIES] any natural subdivision of a species that exhibits small, but persistent, morphological variations from other subdivisions of the same species living in different geographical regions or times: the subspecies name is usually the third term (not capitalized) in a trinomial (Ex.: the scientific name for Neanderthal man is *Homo sapiens neanderthalensis*) —**sub'spe·cif'ic** (-spə sif'ik) *adj.*

subst 1 substantive 2 substitute

sub·stance (sub'stəns) *n.* [OFr < L *substantia < substare,* to be present < *sub-,* under + *stare,* to STAND] 1 the real or essential part or element of anything; essence, reality, or basic matter 2 *a*) the physical matter of which a thing consists; material *b*) matter of a particular kind or chemical composition 3 *a*) solid quality; substantial character *b*) consistency; body 4 the real content, meaning, or gist of something said or written 5 material possessions; property; resources; wealth ☆6 a drug: see CONTROLLED SUBSTANCE 7 *Philos.* something that has independent existence and is acted upon by causes —**in substance** 1 with regard to essential elements 2 actually; really

sub·stand·ard (sub stan'dərd) *adj.* below standard; specif., *a*) below a standard established as by law *b*) *Linguis.* NONSTANDARD (a usually

at, āte, cär; ten, ēve; is, īce; gō, hôrn, look, tōōl; oil, out; up, fur; ə *for unstressed vowels,* as ə in *ago,* u in *focus;* ' as in Latin (lat''n); chin; she; zh as in *azure* (azh'ər); thin, *the;* ŋ as in ring (riŋ) *In etymologies:* * = unattested; < = derived from; > = from which ☆ = Americanism   See inside front and back covers

CERTIFICATE OF SERVICE

I, Francis DiGiovanni, hereby certify that on this 2nd day of February, 2007, I caused a true and correct copy of the foregoing **APPENDIX A TO TRUEPOSITION, INC.'S OPENING CLAIM CONSTRUCTION BRIEF PART 2 A142 – A271** to be served upon the following individuals in the manner indicated below:

Via hand-delivery
Josy W. Ingersoll, Esq.
Young Conaway Stargatt & Taylor, LLP
100 West Street, 17th Floor
Wilmington, DE 19801
jingersoll@ycst.com

Via e-mail
Patrick D. McPherson, Esq.
Duane Morris LLP
1667 K Street, N.W.
Washington, DC 20006-1608
PDMcPherson@duanemorris.com

Via e-mail
Rachel Pernic Waldron, Esq.
Kirkland & Ellis LLP
200 East Randolph Drive
Chicago, IL 60601
rpernicwaldron@kirkland.com

/s/ Francis DiGiovanni
Francis DiGiovanni (# 3189)